Governor's Landslide Task Force

RECOMMENDATIONS FOR IDAHO COMMUNITIES, INFRASTRUCTURE, AND RESOURCES AT RISK FROM LANDSLIDES AND RELATED EVENTS

July 1997

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EXECUTIVE SUMMARY

This report provides the recommendations of a Task Force made up of representatives from federal agencies, state agencies, and the private sector with expertise in and a commitment to reducing the impact landslides, mudflows, and debris flows have on this state’s citizens. As a result of two consecutive major disasters, many of Idaho’s communities, roads, and resources have been adversely affected, and the entire state has felt the economic impact of tens of millions of dollars in response and recovery actions.

The conditions that cause landslides continue to threaten the entire state. To reduce the impact of landslides, the Task Force recommends that the Governor and Legislature:

- Implement a state-wide landslide mitigation plan that would encourage and support local mitigation efforts.
- Assess landslide hazards and produce landslide hazard maps of critical areas.
- Implement avoidance measures for landslide-prone areas including (a) legislation, regulations, ordinances, and zoning to mitigate slope instability contributed by excavations and drainage; and (b) site investigations to define hazards.
- Establish a lead agency to take responsibility for making emergency warning notification.
- Initiate field-based, interdisciplinary technical studies of landslide processes to improve hazard assessment techniques.
- Implement guidelines for activation of geotechnically-oriented rapid response teams.
- Assist cities and counties with funding and technical assistance to implement mitigation activities.
- Update and maintain existing statewide landslide database and provide for periodic surveillance in problem areas.
- Implement a public awareness campaign about landslides.
- Develop a method for prioritizing landslide mitigation projects.

PURPOSE AND METHODOLOGY

Idaho is a mountainous state, and as a consequence considerable development of communities, transportation systems, and their supporting infrastructure have been located in steep canyons and alluvial fans close to rivers. Development of forest and mineral resources has also resulted in roads most intended only for temporary use that now lead to homes and recreational opportunities.

Severe winter conditions beginning in November of 1996 and culminating in a complex of snow damage, flooding, and land failures resulted in a state disaster declaration and a federal declaration of northern and western Idaho counties. Because of the isolation of communities and individuals and widespread damage to roads and environment resulting from landslides and debris flows, a task force was convened to prepare recommendations to the governor regarding the hazard and what can be done to reduce the risk to Idaho’s communities, infrastructure, and resources.

The Task Force first met on February 4, 1997, with representatives from state agencies, federal agencies, and the private sector. Goals were reviewed, a timeline set up, and committees established for the timely preparation of this report.

Goals. Recognizing that financial resources limit the scale of landslide mitigation and that many citizens are fearful of government’s regulatory role, the Task Force’s goal was to prepare recommendations for identifying the threat, defining its consequent risk, and proposing strategies for minimizing the impact of future landslides.

Threats from spring melting and runoff set the Task Force on two paths. One was to prepare this report in the shortest possible time. The other was to prepare for anticipated events resulting from continued risk. The latter resulted in a proposal for a multi-agency rapid response team, a proposal outlined in the Mitigation Committee’s report.

Committees. Four committees were formed:

- Science, to identify conditions that lead to landslides
- Mitigation, to identify actions that can limit the impact of landslides
- Policy, to identify strategies for implementing mitigation actions
- Funding, to identify sources and resources for financing

Methodology. While each committee worked in parallel, the Task Force report began with the findings of the Science Committee. The Mitigation Committee assessed county needs and based its recommendations on these responses and the findings of the Science Committee. The Policy Committee assessed existing mitigation reports and recommended strategies to realize them. The Funding Committee assessed mechanisms for funding. The Task Force then as a whole selected the ten most critical issues, identified potential funding sources, and proposed a timeframe for implementation.

Report Format. The report format focuses on the ten recommendations that the Task Force felt to be critical to coping with landslide hazards in the state. These recommendations are based on the individual committee reports, each of which provides recommendations specific to that committee’s point of view.

RECOMMENDATIONS

Recommendations of each committee and the assumptions that drive them are found in the reports of each committee. Below are ten recommendations derived from the committee reports and prioritized by the Task Force.

Recommendation 1. Implement a state-wide landslide mitigation plan that would encourage and support local mitigation efforts.

Recommendation 2. Assess landslide hazards and produce landslide hazard maps of critical areas.

Recommendation 3. Implement avoidance measures for landslide-prone areas including
(a) legislation, regulations, ordinances, and zoning to mitigate slope instability contributed by excavations and drainage; and
(b) site investigations to define hazards.

Recommendation 4. Establish a lead agency to take responsibility for making emergency warning notification.

Recommendation 5. Initiate field-based, interdisciplinary technical studies of landslide processes to improve hazard assessment techniques.

Recommendation 6. Implement guidelines for activation of geotechnically-oriented rapid response teams.

Recommendation 7. Assist cities and counties with funding and technical assistance to implement mitigation activities.

Recommendation 8. Update and maintain existing statewide landslide database and provide for periodic surveillance in problem areas.

Recommendation 9. Implement a public awareness campaign about landslides.

Recommendation 10. Develop a method for prioritizing landslide mitigation projects.

SCIENCE COMMITTEE REPORT

In order to serve the needs of Idaho's citizens, effective mitigation measures must be introduced to reduce landslide hazards. A prerequisite for these mitigations is a solid foundation of technical knowledge about Idaho's unique landslide hazards. Therefore the following recommendations emphasize both the short- and long-term need for comprehensive technical information. Implementing these recommendations will require adequate and substantial funding:

- Carry out landslide hazard assessments and produce landslide hazard maps of critical susceptible areas.
- Formulate a Landslide Hazard Mitigation Plan.
- Initiate field-based interdisciplinary technical studies of landslide processes.
- Update the existing Idaho State Landslide Information database.
- Assess adequacy of Idaho's weather station network and implement studies to address climatological questions related to rainfall thresholds and landslide occurrence.
- Include scientists (e.g., geologists, hydrologists, soil scientists, or geomorphologists) alongside disaster officials on emergency rapid response teams.
- Develop a public education and technology transfer plan.

I. INTRODUCTION

Idaho's geology, landscape, climate, soils, and other factors locally are conducive to landslide activity. Idaho's history of landslides in the 20th Century reflects this persistent hazard: major landslide events have had a significant impact on transportation, communities, and natural resources in 1919, 1934, 1948, 1964, 1968, and 1974. We cannot entirely prevent the natural process of landslide movement, but we can in many cases take actions to mitigate (alleviate) hazards due to landslides. Up to now, most available resources have been directed toward cleanup rather than mitigation. A prerequisite of effective mitigation is an adequate base of technical information, including landslide hazard maps which address Idaho's particular terrain, geologic, and climatic characteristics. Furthermore, understanding the specific causes of landslides involves investigating the poorly-understood interactions between natural and human factors. These complex interactions are poorly-enough understood that effective mitigation efforts are seriously hindered. The role of the scientific community in this arena is to provide high-quality, unbiased information which then can be used by local and state governments, state and federal land management agencies, and private and corporate organizations to mitigate landslide hazards in Idaho. A commitment both to short-term technical data-gathering and to longer-term research is needed to adequately assess Idaho's landslide hazards and to implement potential solutions.

II. LANDSLIDE HAZARDS

A. Defining Landslides

A landslide is defined as the (sometimes sudden) downslope movement of a volume of rock or earth due to a failure of the material. There are many different kinds of landslides, all with different names. For convenience and stylistic brevity, we use the term landslide in this report to describe any downslope movement of surface materials, regardless of the type of material involved or the mechanism or style of movement (e.g., debris flow, rock slide, etc.).

For a safe and stable slope, the slope mass is in equilibrium as long as the stresses in the slope do not exceed the strength of the material. However, if these stresses increase, or if the strength of the material decreases, a critical condition is surpassed and the slope fails. A common cause of failure is the infiltration of water into the slope, which usually leads to an increase in ground stresses and a reduction of the soil's strength.

An understanding of the types of landslides that occur and the processes that cause slope movement is fundamental to assessing landslide hazard and evaluating potential mitigation measures. Below we present a brief description of some of the different types of landslides. Many types of landslides have occurred in Idaho, but in the following discussions we emphasize the types that most commonly present hazards in the state. Figure S-1 illustrates the types of landslides most common in Idaho. The text, *Landslides: Investigation and Mitigation* (Turner and Schuster, 1996) may be consulted for more information. Another useful reference is a map showing landslides in Idaho, published by the Idaho Geological Survey (Adams and Breckenridge, 1991)

The simplest systems for classifying landslides are usually based upon two elements: the type of material mobilized and the type of movement (e.g., Varnes, 1978). An abbreviated version of such a classification is shown in Table 1. The types of movement include falls, topples, slides, spreads, and flows and the types of material include bedrock, debris (coarse material), and earth or mud (fine material).

Table 1 Types of Slope Movements (Cruden and Varnes, 1996)

Type of Movement	Type of Material		
	Bedrock	Predominantly Coarse (Debris)	Predominantly Fine (Earth)
Fall	Rock fall	Debris fall	Earth fall
Topple	Rock topple	Debris topple	Earth topple
Slide	Rock slide	***Debris slide***	***Earth Slide***
Spread	Rock spread	***Debris spread***	***Earth spread***
Flow	Rock flow	***Debris flow***	***Earth flow***

Slope movements that are most likely to occur in Idaho and present hazards as a result of events like the 1997 New Year's rain-on-snow event are shown in italics. Note that, although these types were locally the most common during the New Year's event, they are by no means the only types of slope failures which occurred, or which can be expected to occur in the future.

The name of a landslide can be modified with adjectives to more precisely communicate its properties. Typically these are used to describe its current state of activity (active, inactive, etc.), style (complex, simple, etc.) and so on.

B. Hazards Due to Landslides

The terms “hazard” and “risk” are often used but rarely defined when discussing landslides. For the purpose of this document, a hazard is defined as a source of danger. Risk is an evaluation of potential loss or injury resulting from a hazard. There is no fixed relationship between hazard and risk because the same landslide could cause vastly different amounts of damage depending upon its location and path.

The principal consequences of landslides in Idaho occur directly at the site and downslope of the landslide, and in adjacent waterways. At the landslide site itself property, habitat, and organisms in the pathway are directly impacted by the material carried by the slide. Landslides also change topography, which in turn may enhance future risk. Stream systems are effected downstream of landslides, chiefly by increased sediment inputs. If a large amount of material enters a stream channel, temporary (in extreme cases, permanent) flooding caused by debris dams. These impacts will be discussed in greater detail in Section IV of this report.

C. Factors Contributing to Landslides

Natural Factors

Natural factors contributing to landslides include slope morphology (shape), slope material (soil), bedrock geology, vegetation, and climate. Generally, the steeper a slope is, the more prone it is to landsliding up until the point at which it is so steep that loose material does not accumulate. In a study of landslides on the Idaho batholith, Megahan and others (1978) found that most slides occurred on slopes of about 30 degrees and that landslides were rare on slopes steeper than 41 degrees. In addition to slope steepness, the concavity of a slope greatly influences the likelihood of a landslide. In a concave slope (e.g., hollow, swale, gully), water and colluvium tend to concentrate, whereas on a convex slope (e.g., ridge, nose), water and colluvium are less likely to accumulate.

The properties of slope surface materials and their underlying geology are also key factors in determining landslide risk. The most important properties of the surficial slope material (generally referred to as “soil” by engineering geologists), with respect to landslide risk are: (1) shear strength (and how it varies with wetting), (2) hydraulic conductivity (how water moves through porous material), and (3) the stratigraphy of the material (layering and how shear strength and hydraulic conductivity vary in space). A landslide is most likely to occur in the weakest portion of the slope as a result of a unique triggering mechanism. For example, if an impermeable layer exists in the slope material, subsurface water will accumulate there, resulting in increased pore-pressures, leading to reduced shear strength and thus a potential failure plane for a landslide. The underlying and adjacent geology often influence the location and occurrence of landslides by controlling the movement of groundwater and springs as a result of fractures and zones of reduced hydraulic conductivity.

Vegetation contributes to slope stability in two ways. First, roots increase the shear strength of the slope material, and secondly, vegetation removes water from the hill slope by evapotranspiration. If the water table in the hill slope is lower as a result of transpiration, the pore pressures in the soil are lower, and the thus the shear strength is higher and the slope is more stable (all else being equal).

The climate of a region determines the frequency and magnitude of precipitation events that may trigger landslides. It also partially controls the processes of rock weathering (important in influencing soil depth and strength), the type of vegetation that occupies the hill slopes, and the fire regime of the region. All of these elements influence landslide hazard but it is the size and timing of precipitation events that have the greatest impact on landslide risk.

A common tool for describing the magnitude of a climatic event is to estimate its return interval (similar analyses are done for floods, fires, etc.). This relies on past historical data to predict future occurrences. For example, a 50-year storm would be one that has a 1 in 50 chance (2%) of occurring in *any* given year. It is incorrect to assume that if a 50-year storm occurred this year, we have 50 years until another storm of a similar magnitude occurs. *There still is a 2% chance that the event will re-occur the following year.* Two complications in estimating the frequency of climatic events often confound our efforts to assess future hazards: inadequate historic records and the possibility of climate change.

Human Activities

Some human activities and land uses are likely to increase the potential for landslides on steep slopes. These activities include road construction, timber harvesting, grazing, mining, and long-term fire suppression. As a group, these activities can contribute to slope instability by changing infiltration and subsurface water transmission, decreasing the protective role imparted by vegetation, or oversteepening slopes. Megahan and others (1979) inventoried over 700 landslides in the Payette River drainage. In the most recent activity, less than 3 % of observed landslides occurred on undisturbed sites, whereas the rest were associated with forest disturbances including wildfire, timber harvesting and roads. However, it is the extreme storm events that are the dominant variable affecting landslide activity. Landslide activity in this study was concentrated during years with extreme storm events. A short discussion of causal mechanisms and ways to mitigate follows.

Placing roads on steep slopes has been widely identified as the single human activity most likely to increase the potential hazard of mass instability on a site. Roads increase the amount of bare soil, and if constructed on sideslopes, always result in a portion of the road fill being steeper in gradient than the natural slope. Road construction on slopes also changes the way water is transported. Excavation results in a disruption of subsurface transport through soil pores, diverting this water to the surface, where it is concentrated and flow velocity is much greater. Often this redistribution of water increases the probability of atypically high pore pressures in some locations decreasing soil strength. Mining activities that affect slope stability are similar to road construction, and require the same mitigative measures. However, the problems are usually restricted to the mine pit.

Proper mitigation for increased hazards from roads includes good design and careful construction. Gonsior and Gardner (1971) suggest that: (1) Fill slopes should be specified by a design engineer based on appropriate stability analysis; (2) Alignment should be sacrificed wherever possible to avoid deep fills and cuts; (3) All fill slopes should be compacted to a degree consistent with design standards and material properties; (4) Drainage facilities should be provided to prevent concentrations of surface runoff and to avoid high pore pressures in cuts and fills; and (5) Specifications requiring log and debris removal from the foundations underlying fill slope sections must be rigidly enforced.
Both timber harvesting and crown-killing fires remove many of the beneficial effects of live trees, namely water removal by transpiration, and added soil strength from roots. Fire-induced water repellency in surface soils increases the chances of overland flow and hyper concentrated flood events in channels. Prior fire suppression activities by land management agencies have contributed to an increased incidence of severe wildfire because of fuel buildup on forested sites. Mitigation for timber harvest includes recognizing and avoiding timber harvest in landslide prone areas, and protecting riparian corridors with adequate buffer zones. Changing fire management policies to allow

reintroduction of fire and tree thinning to reduce fuel buildup and return forests to natural fire regimes may prove helpful in mitigating for severe wildfires.

In the first half of the 20th Century, grazing was widely implicated as a cause of accelerated mass erosion on rangelands in southwest Idaho, principally because of loss of vegetative cover and trampling effects that decreased water infiltration capacity of the soil. Grazing pressures have declined over the last few decades, however it is not clear if a legacy of effects still exists. Introduced exotic plant species are so prevalent on southwestern Idaho rangelands that it may be impossible to sort out effects of grazing from vegetation change. Mitigation for grazing effects involves grazing strategies that allow for plant recovery following the period of grazing, and maintenance of soil surface conditions that allow water infiltration.

Irrigation and others forms of introduction of additional water (e.g., sprinklers, injection wells, and even septic systems) may be locally contributing factors to slope instability in rural and urban settings. This may be critical along the Snake River canyon and near urban centers.

Landslide Triggers

Many factors contribute to landslides (topography, geology, soils, human activity, etc.) but only a single trigger initiates a particular landslide (Wieczorek, 1996). Typical triggering events include (alone or in combination): intense rainfall, rapid snowmelt, seismic activity, volcanic eruptions, and the rapid erosion of the slope toe material (e.g., by stream downcutting or road excavation).

In the case of the widespread landsliding associated with the 1997 New Year’s Flood in western Idaho, the combination of unusually high precipitation and associated rapid snowmelt (rain-on-snow) was the triggering event for most landslides (see following section). It is also likely that the associated stream flooding eroded the toes of some slopes causing some landslides. The introduction of large quantities of water to slopes can trigger landslides in two primary ways: (1) the water can infiltrate into the slope and reduce the strength of the slope material (elevation of pore pressure sometimes coupled with changed material properties when wetted such as with swelling clays), and (2) the water can concentrate on the surface as runoff to initiate a debris flow which bulks up (gains sediment) as it moves down the slope. Often, a combination of the two mechanisms will occur for a given landslide, but usually one is dominant.

III. SUMMARY OF DECEMBER 96 – JANUARY 97 LANDSLIDES

A. Antecedent weather/moisture conditions

Northern Idaho. The boundary of the cold Canadian air and the westerly flow across the Pacific Ocean stalled across the Idaho Panhandle in mid and late November. This directed a series of weather disturbances over the area at frequent intervals.

Snow began in the Idaho panhandle on November 16, 1996, resulting in heavy snow accumulations. Weather reporting stations in the populated valleys on the morning of November 19, 1996 generally had between 12 and 20 inches of wet snow on the ground, with Bonners Ferry reporting 27 inches. Unofficial reports in the valleys and mountain locations indicated even higher amounts.

A few factors combined to make this a unique weather event. High temperatures generally never got above the middle 30s and low temperatures were mostly in the 20s. This enabled the snow pack to persist throughout the month. Additional rain and snow events occurred for the remainder of the month which consolidated the snow pack, snow depth measurements went down some days as rain and settling occurred, then additional snow brought totals right back up. The water content of the snow became very high as a result of the warmer temperatures and additional wet snow and rain. A further complicating factor was that cold air stayed trapped in the valleys, which resulted in freezing rain on many occasions, while at the higher elevations precipitation continued to fluctuate between rain and snow.

Precipitation for the month of November was well above normal for all reporting stations. In just a 12-day period, November 17-28, reporting stations received what they usually receive in moisture for the entire month, and some locations received much more.

The ensuing weeks in December brought more of the same. Another cold outbreak brought a return of the same pattern. High temperatures seldom got above the mid 30s and low temperatures varied between the teens and 20s. In the first two weeks of the month, only one day did not have precipitation. Snow depths began increasing again, and by the morning of December 5, 1996 were mostly in the 24-36 inch range. Again, due to temperatures, this was rather wet snow, on top of the existing consolidated snow pack.

Precipitation amounts were generally light during the period December 15-18. Precipitation began again on the 19th, with only one day without precipitation for the rest of the month. Reported snow depths continued in the 2-3 foot range through the month, indicating more consolidation (increased snow density) due to the additional precipitation and daytime temperatures.

Southern Idaho. Cold Canadian air moved to southern Idaho in mid-December. Wet Pacific weather systems moving over this cold air brought considerable snow to central and southern Idaho. Boise, Idaho received its second highest 24-hour snowfall (9.8 inches) on December 20, 1996. Both high- and low- elevation snowpack was well above normal. A rapid warming occurred beginning Christmas eve as very warm, wet weather systems came into the area from the tropical region near Hawaii. This moisture stream persisted for days, not ending until early on January 3, 1997. Total rainfall amounts for the period December 24, 1996 through January 2, 1997 for selected stations in southern Idaho are given in Appendix S-1 and shown on the map in Figure S-2. The combination of a heavy snow pack, well above normal temperatures (50s during the day and near or above freezing at night) to melt the snow pack, and days of moderate rain, brought significant runoff in all southern basins. This combination brought rapid river flooding and debris flows from supersaturated soils.

Precipitation amounts were at near-record levels for southwest Idaho in December. Reporting sites received between 3 and 4.6 times their normal December precipitation. With the initial precipitation occurring as snow, then days of moderate rain and well-above-normal temperatures, the runoff was excessive, bringing record or near-record floods on the Payette and Weiser Rivers. Many smaller, ungauged streams were flooding as well. Soils were supersaturated, resulting in rock and mud slides, especially on steep terrain. The high inflow from these basins also brought the Snake River at Weiser well above flood stage, with additional flooding on the Snake River downstream at Anatone.

Heavy rain and mild conditions continued on the first two days of January 1997. Some southwest Idaho locations received close to their normal January precipitation on just those two days. Temperatures were very mild, with 50-degree and some lower 60-degree readings. This continued the snowmelt at mid elevations. A colder, drier air mass came across the area beginning on January 3, 1997, bringing an end to the precipitation and an end to the snow melt.

As noted above, there was a series of weather systems in a persistent weather pattern that affected Idaho throughout this period. The series of events started with the northern Idaho snow on November 16, 1996. It ended with the change to cool, dry air mass on January 3, 1997.

B. Geologic, Soil and Geomorphic Setting

Readers should keep in mind that this section of the report reflects the experience and expertise of the authors in mainly southern and central Idaho; it does not fully represent the geologic, soil, and geomorphologic character of northern Idaho, where the natural setting contributes to equally hazardous, but somewhat different landslide hazard conditions.

Geology. Idaho's geology is diverse and includes a number of different geologic settings. A simplified geologic map of Idaho is shown in Figure S-3. Common factors to most areas are the steep slopes and high relief, attributable to the state's ongoing geologic history of uplift and erosion. Even in the relatively flat Snake River Plain and Owyhee County regions, numerous landslides occur along the near-vertical walls of deeply-incised river canyons.

Central Idaho geology is dominated by the Idaho batholith, a 70-to-100-million-year-old, deeply eroded complex of coarse-grained intrusive igneous rocks, generally classified as granite. Although the Idaho batholith is often considered to be uniform in composition throughout, this is incorrect on the scale relevant to landslides. Local variations in the types and proportions of minerals may affect weathering rates and soils that are produced. The batholith rocks are highly fractured and are crosscut by numerous large and small faults, sheared zones, and younger Tertiary (mostly 35-50 million year old) dikes and plutons. All of these help generate zones which tend to be more prone to landslides than others. In the most severe cases, the granitic rocks have been ground up by fault movements, so that the once competent rock consists of broken, sand-size grains, rock flour or brecciated material, all with much less strength than the parent material.

Basalt is another common rock in western Idaho (see Fig. S-3). This basalt is part of one of the most voluminous outpourings of basaltic lava in North America: the Columbia River Basalt Group. Most of the Columbia River Basalt was erupted in what is now Washington and Oregon, but lobes or tongues of basalt flowed into parts of what is now western Idaho during the interval of 14 to 17 million years ago. Layer upon layer of fluid basaltic lava interspersed with sediment and ash accumulated in great thicknesses, locally up to 3000 feet. Today eroded remnants of these basalts form prominent tablelands and cliffs in western Idaho. In some places basalt flowed over the Idaho batholith, but locally (e.g., along U.S. Highway 95 between New Meadows and Riggins) the basalt caps much older metamorphic rocks. The steep, deeply eroded canyons of the Little Salmon and Salmon Rivers expose these older rocks. Rockslides and rockfalls are common geologic hazards in such terrain.

Precambrian (about 1,400-million-year-old) Belt Supergroup metamorphic rocks are the dominant lithology in northernmost Idaho. These rocks are strongly layered, a structural feature which promotes block slides and rockfalls (Figure S-1), especially when the layering is unfavorably oriented with respect to the hillslope. Locally the rocks contain micas, minerals which contribute to the tendency toward instability.

Soils. Upland soils in Boise and Valley Counties and adjacent areas that experienced widespread slope failures (shallow landslides, debris flows, etc.) are predominantly formed from granitic or basaltic parent materials. These two parent materials form soils with very different properties. Granitic rock from the Idaho batholith is coarse grained, and weathers to form soils with a coarse texture (dominantly sandy loam or loamy sand textures) that are cohesionless and highly erodible. In mountainous areas granitic soils are often shallow, less than 20 inches (50 cm) in depth; however, rock below the soil horizons is frequently fractured and weathered, increasing the effective soil depth for rooting, water transmission, etc. Granitic soils are highly permeable unless they are compacted by grazing, timber harvest activities, or off-road vehicle use. Infiltration capacities are high (generally several inches per hour), and surface runoff is rare; however granitic soils may form water-repellent surface layers that may persist for two or more years following intense wildfires. Water holding capacities of granitic soils are relatively low because of the large pore size distribution.

Soils formed from basalt parent materials have finer textures (typically loams or clay loams), and have lower infiltration capacities, lower permeabilities, but higher water holding capacities. These soils have more cohesion (capacity to adhere or stick together) and resistance to erosion than granitic soils, and are generally more productive. Basalt soils are more subject to compaction by grazing and logging activities than granitic soils.

The resistance of granitic and basaltic soils to sliding is strongly influenced by their cohesion. For granitic soils, most of the cohesion is provided by roots. Disturbances to natural vegetation from wildfire or logging have the potential to increase the probability of landslides by decreasing root strength and increasing water in the soil because of reduced plant water use.

Geomorphology. The geomorphic setting of the portion of Idaho impacted by the January 1997 landslides is controlled largely by its underlying geology (discussed above). The landscape is characterized by great relief (>4000 feet), steep slopes, narrow V-shaped valleys, and gently rounded ridges. Forested areas are typically characterized by few trees on the south-facing slopes and heavily forested north-facing slopes. Both surface erosion and mass erosion (landslides) have shaped the topography. Headwater channels in this region are steep and historically have been the site of debris flows. Many of the larger stream channels are confined by valley walls and more recently, roadways and railroads.

C. Highlights of January 1997 Landslides

Description of Impacts

Landslides occurred throughout southwestern and west-central Idaho during the December 1996-January 1997 event. The landslides were associated with heavy and prolonged precipitation, warm temperatures, and certain landscape, geologic, and soil characteristics. Landslides were clustered within particular areas or regions, possibly due to combined locally heavy and prolonged precipitation with other contributing factors such as soils or landscape characteristics. Many of the landslides seem to have been confined to elevations between about 3000 and 5000 feet. This observation suggests the importance of the unusually high freezing level and the effect of rainfall upon snow in triggering landslides. The effects of these failures include damage to and resulting closure of highways (and resulting isolation of communities), destruction of power and telephone lines, burial and flooding of buildings and vehicles, and damming and sedimentation of rivers.

Reports indicate that many of the damaging landslides occurred on December 31, 1996 and January 1, 1997, although sporadic road closures due to blocking by mud and debris were reported on December 30. A map showing general areas known to have undergone intense landslide activity at this time is given in Figure S-4. (This map also shows areas where landslides have caused damage in previous years). A complete inventory of landslide and damage occurrences for the New Year's storm is not available at this time. The map is necessarily incomplete because it is likely that many landslides occurred in inaccessible regions and have not yet been observed firsthand. However, the following areas are known to have been heavily impacted by landslides:

Old Hwy 17 and South Fork Payette River, here called the "Banks-Lowman corridor." This area was one of the most heavily impacted, both in terms of number of slope failures and resulting damage. Slope failures were particularly abundant between Garden Valley and Lowman. Here, countless small, shallow debris flows (as well as several larger, longer flows) began on south-facing slopes between about 4800 feet and 5000 feet elevation. Many of these did not travel far and did not cause immediate damage to roads or property. Many more, however, deposited sufficient sediment and debris on the roadbed to make the road temporarily impassable in numerous places. Notable property damage occurred at the mouths of Russell Creek and Carpenter Creek (Figure S-5). Total cost estimates to repair the road approach $2.5 million.

A remarkably large and destructive debris flow occurred along Hwy 17 in an uninhabited area about 4 miles east of the confluence of the South Fork and the North Fork, at a place called Bronco Billy Rapid. This debris flow, one of the largest observed in the Garden Valley area, differs from many others because it occurred in a drainage with significant bedrock exposure in its lower portion, carried material from several coalescing drainages (total vertical relief >3000 feet), and bore a significant component of very large boulders. Like many debris flows, it occurred in more than one pulse , according to eyewitness accounts. Debris flowed across the road and into the South Fork of the Payette, where it created a debris dam, causing local flooding and burial of the roadbed to an estimated 12 feet depth (Idaho Transportation Dept). Of the many locations where debris flows blocked or buried the roadbed along the South Fork, this locality had the most impact in terms of preventing access to Garden Valley and Lowman, because debris and water blocked the road for several days. Even in April, nearly 4 months later, the road is open only on a controlled basis. The roadbed in this location will need to be permanently elevated because the configuration of the streambed has been significantly altered. This example demonstrates how the secondary effects of landslides (in this case, flooding) can be equally damaging and can considerably compound the hazards. The estimated cost to repair the road at this site was nearly $352,000.

Community of Lower Banks . On January 1, 1997, debris flows containing a large volume of water and sediment flowed from the watershed above the community of Lower Banks onto the apex of the alluvial fan at the base of the drainage, across Hwy 55, and into the Payette River. An estimated 200,000 to 250,000 cubic yards (ITD) of debris was washed from the basin, carried by approximately 34 acre-feet of water. Structures on the fan were damaged or destroyed either by impact from boulders and other debris (boulders up to 5 feet in diameter were deposited on the fan) or by filling with mud and sediment. The debris flow destroyed existing sewer systems for 5 mobile homes, 4 cabins, a motel, and an RV park. Severe damage also occurred to the water distribution system for most of the homes on the fan. The continuing threat to human life presented by saturated soils and ongoing or incipient slumps in the canyon and the difficulties of mitigating debris flow hazards in this case prompted a recommendation that the community be permanently evacuated (Interagency Technical Report, Feb. 5, 1997). The Federal Highway Assessment Team estimated road repair costs at this site alone to be about $303,000.

Hwy 55 between Horseshoe Bend and Cascade. The Idaho Transportation Department was plagued by numerous mudslides in this region (including, but not limited to, the Lower Banks site described above). At milepost 101, 1.1 miles north of Rainbow Bridge, a retaining wall failed and the road shoulder eroded. Travel was restricted for several weeks while repair crews replaced the wall and repaired the roadbed. Repair costs are estimated at $321,425.

Hwy 95 between New Meadows and Riggins (Little Salmon River drainage). Numerous rockfalls and mudflows, combined with flooding, completely closed this critical north-south route for about 4 days, and travel was restricted for about 11 days. Repair estimates in this region (including damage by flood waters) exceed $3 million, but about $2.5 million is attributed to flood damage.

South Fork Salmon River. A complete assessment of damage in this basin will not be available until access is gained for the summer, but the Payette National Forest reports severe damage to the South Fork Salmon River Road by landslides and debris flows. Damage was inventoried at 106 sites along this road alone, and ranged from small landslides that blocked drainage ditches to large landslides that destroyed the entire road prism. The community of Yellow Pine and the Stibnite Mine were isolated for 8 days.

North Fork Boise River . Descriptions and extent of damage not available at this time.

Hwy 21 between Lowman and Idaho City (particularly north of Mores Creek Summit). Debris flows caused road damage which, combined with Hwy 17 closure, isolated the communities of Garden Valley and Lowman. Three major roadway washouts occurred between 1.7 and 4.4 miles south of Lowman (milepost 67.8 to 70.5). In addition, landslides and debris flows caused extensive damage south of Idaho City and south of Lowman. The road was closed for about 8 days. Total repair costs for this highway are estimated at about $1.3 million.

Transportation Corridors

Transportation corridors in Idaho were severely disrupted by landslides and related events during this period. Although flooding and undercutting of roadbeds by high water caused many road closures, landslides (debris flows) were the major cause of transportation disruption on Idaho 55 near Banks, US 95 north of New Meadows, and Idaho 162 near Kamiah. Despite ITD's heroic efforts to keep roads passable, there were simply too many slides. Idaho 55 was closed near Banks on December 30, reopened early on December 31, closed again on January 1, and remained closed until January 8. US 95 north of New Meadows was open intermittently on December 31 but was closed on January 1 through January 4. Idaho 162 near Kamiah was closed on Dec. 30 and 31, and again from Jan. 1 until Jan. 8. Other extended road closures included Idaho 21 between Idaho City and Lowman, US 71 west of Cambridge, and Idaho 14 at milepost 4.2. In many cases, truck traffic was restricted even longer due to the fragile condition of the road. The economic impacts of this transportation disruption were not estimated as part of this report, but they are undoubtedly substantial. See Appendix S-2 for a more detailed chronology of road closures between December 30 and January 8.

Impact of Landslides on Other Resources

Much of the impact of the 1997 landsliding is not yet known because a large portion of the area is still covered by snow at the time this report was being prepared. This discussion is based on similar events that have occurred in the past and reported in the literature. Often the losses that are most visible as the result of a disaster are those that immediately have a direct and adverse impact on humans and commerce. Although these losses are often acute, they usually occur on only a small proportion of the land impacted. This discussion will certainly raise more questions than it will answer, largely because these impacts have not yet been investigated for this event.

Much of the impact of the 1997 landslides occurred on virtually unpopulated public and private lands managed by the Forest Service, Bureau of Land Management, Idaho Department of Lands, and Boise-Cascade. The impact included damage to infrastructure (e.g., forest roads), but also represented an episodic input of sediment and woody debris into stream channels. The increased sediment input into the stream channels probably had both benefits and adverse impacts for fish habitat. The input of coarse material (gravel and boulders, woody debris) almost certainly contributed to maintaining the complex and diverse habitat that many species have evolved with. The intrusion of large concentrations of fine (silty) sediments, such as from a road fill failure, probably had adverse impacts on habitat by contributing to a local degradation of spawning habitat and pool filling.

Although we know that management activities have often increased landslide hazards, the implications and mitigation alternatives of this are unclear, particularly for aquatic ecosystems. Studies conducted in the coast ranges of the Pacific Northwest have demonstrated increased landsliding as the result of the loss of root strength and reduced transpiration after clearcutting. Studies in Idaho have shown that the majority of landslides in forested terrain are the result of roads (Megahan, et al., 1978). A key element of the effect of this on aquatic ecosystems, is the timing, quantity, and size of the material that is eventually delivered to the stream channels. For example, road fill failures that do not deliver sediment to a stream channel may require little or no mitigation.

Recent wildfires may also have played a role in the extent and severity of the landsliding by (1) reducing root strength, (2) reducing transpiration by plants, and (3) increasing runoff due to reduced infiltration. If this is the case, a strategy for reducing landslide (and flood) hazards might be to treat forest health problems. This should be investigated.

Because most of the streams in Idaho that are considered “water-quality limited” (and thus require TMDLs: total maximum daily sediment loads) are so designated because of perceived excessive sediment inputs, the public policy implications of additional sediment from the 1997 landslides may be considerable. In some places, much of this additional sediment probably had little or nothing to do with human activities and the listing of such streams as not supporting beneficial uses is unwarranted. In other locations, human activities may be the source of excessive sediment, and mitigation measure can be employed. A landslide hazard analysis and sediment budgeting can facilitate determining which areas are in which category to permit the targeting of finite mitigation resources and to prevent arbitrary restrictions on land use.

Continuing Hazards

The Weiser and Payette River basins hold snowpacks that represent 126% of the average amount of stored water; the Boise River basin contains 148% of average. Sudden warming and resultant snowmelt this spring, especially if accompanied by additional rainfall, could result in conditions similar to those experienced in late December 1996 and early January 1997. At the time of this writing, low rainfall totals for February and March and a slow warming trend accompanied by cool nights have eased, but not eliminated, concerns for further landslides in those already-damaged areas. Indeed, landslides on March 13 on Hwy 12 near Lenore and on March 26 on US 95 near Bonners Ferry are reminders that landslides are a continuing hazard. Debris flows in mountainous terrain are a year-round threat and may be triggered by heavy, brief rainfall during summer thunderstorms. Burned watersheds are particularly vulnerable to debris flows, because the protective vegetation has been removed and burned soils tend to promote overland flow of water, and hence increase erosion.

V. RECOMMENDATIONS

Nearly two centuries of scientific studies of landslides throughout the world have established a basis for understanding causes and mechanisms of landslides. It is understood that both natural and human-controlled factors may work separately or together to cause landslides. However, it is not yet a simple problem for scientists to isolate causes and mechanisms of landslides in a general and predictive way. In Idaho we are currently quite far from being able to formulate specific recommendations for mitigation or prevention of landslides, because we lack an adequate base of technical information for the particular problems that Idaho's diverse geology, soils, climate, and landscape present.

In order to serve the needs of Idaho's citizens, we must first establish the technical basis for specific mitigations. *Without those scientific underpinnings, the gap in our understanding of the subtle interactions of natural and human causative factors will continue to hinder landslide mitigation* *efforts, and we will continue to merely treat the results of landslides, without effectively mitigating the hazard.*

Therefore the following recommendations emphasize short- and long-term needs for technical information rooted in comprehensive data gathering, interpretation, and sound scientific research. A strong financial and philosophical commitment is essential to achieving these goals.

Recommendation 1: Develop a Hazard Assessment, including reliable landslide hazard maps, of critical landslide-prone areas in Idaho as a resource and planning tool for federal, state, and local planners and other decision makers. This assessment could be led by the Idaho Geological Survey, in cooperation with state universities and land management agencies as well as appropriate federal agencies. The goal of the assessment will be to identify vulnerable communities, lifelines, areas, facilities, and natural resources so that effective mitigation measures can be emplaced.

To enable new work to be compatible with previous studies, the Science Committee recommends that future landslide hazard studies use the U.S. Forest Service's hierarchical framework (Land Systems procedure) as a basis for organizing and interpreting landslide information (see Wilson, 1985). This will greatly aid in identifying and prioritizing areas for hazard assessment.

Landslide hazard maps are an integral part of landslide hazard assessment. They show where landslide processes have occurred in the past, where they occur now, and the probability in various areas that landslides will occur in the future. These maps require analysis of factors such as geology, soils, vegetation, landscape attributes, and land use, and should recognize different kinds of hazards from different types of slope failures.

Recommendation *2:* Formulate a Landslide Hazard Mitigation Plan similar to plans adopted by Colorado and other states. The critical ingredient of any landslide mitigation plan is a sound technical understanding of the hazards, as described in Recommendation 1. Details of formulating and implementing a hazard mitigation plan are addressed by the Mitigation Committee's report.

Recommendation 3: Update the existing Idaho State Landslide Information database and assure that support is available to maintain it as a visible, practical resource for planners, local governments, and other users.

Recommendation 4: Initiate field-based interdisciplinary research studies aimed at understanding processes, mechanisms, and characteristics of landslides/debris flows. These studies enable more accurate assessment and mitigation of hazards by enhancing our knowledge of how and why landslides occur (or don't occur). An excellent example of a cooperative, interdisciplinary investigation is the recently-completed study by the Clearwater National Forest and Potlatch Corporation to investigate the devastating landslides of November 1995-February 1996 (see Appendix S-3).

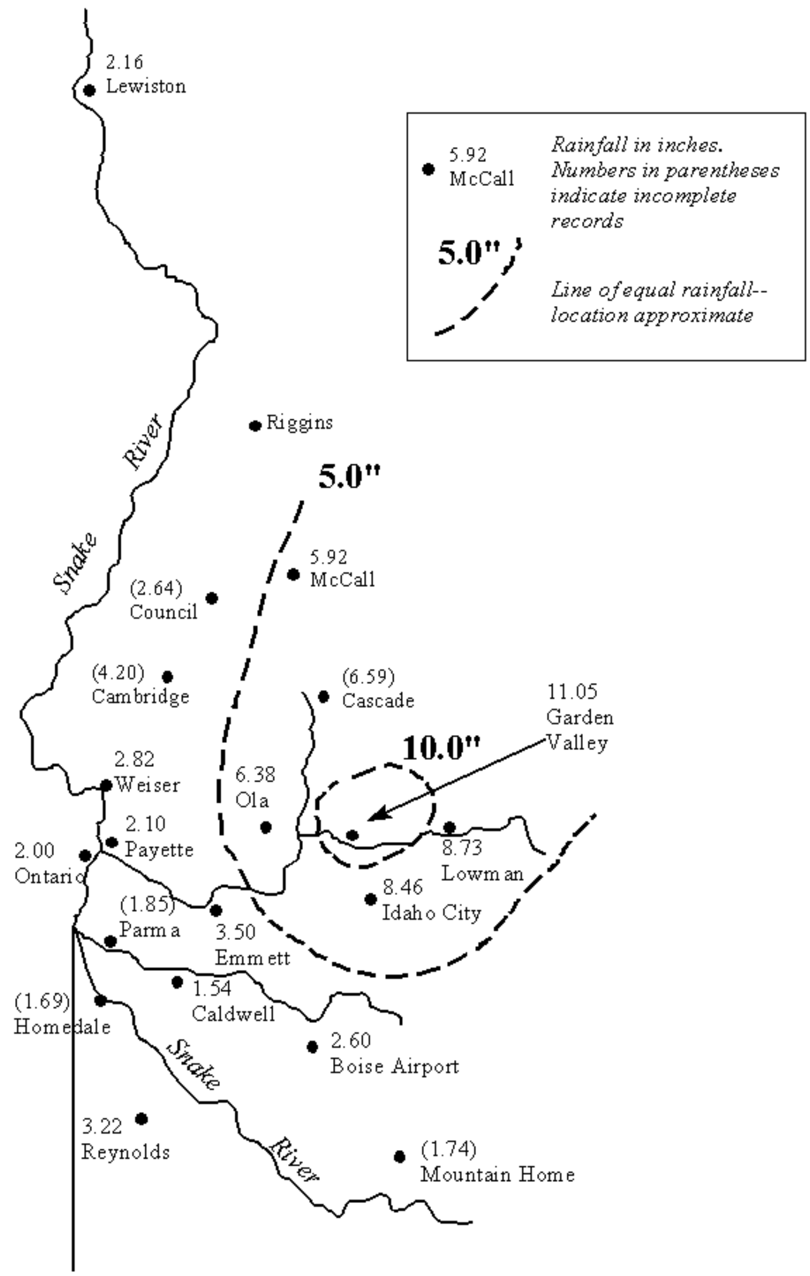
Recommendation 5: Address climatological questions related to landslide occurrence by:

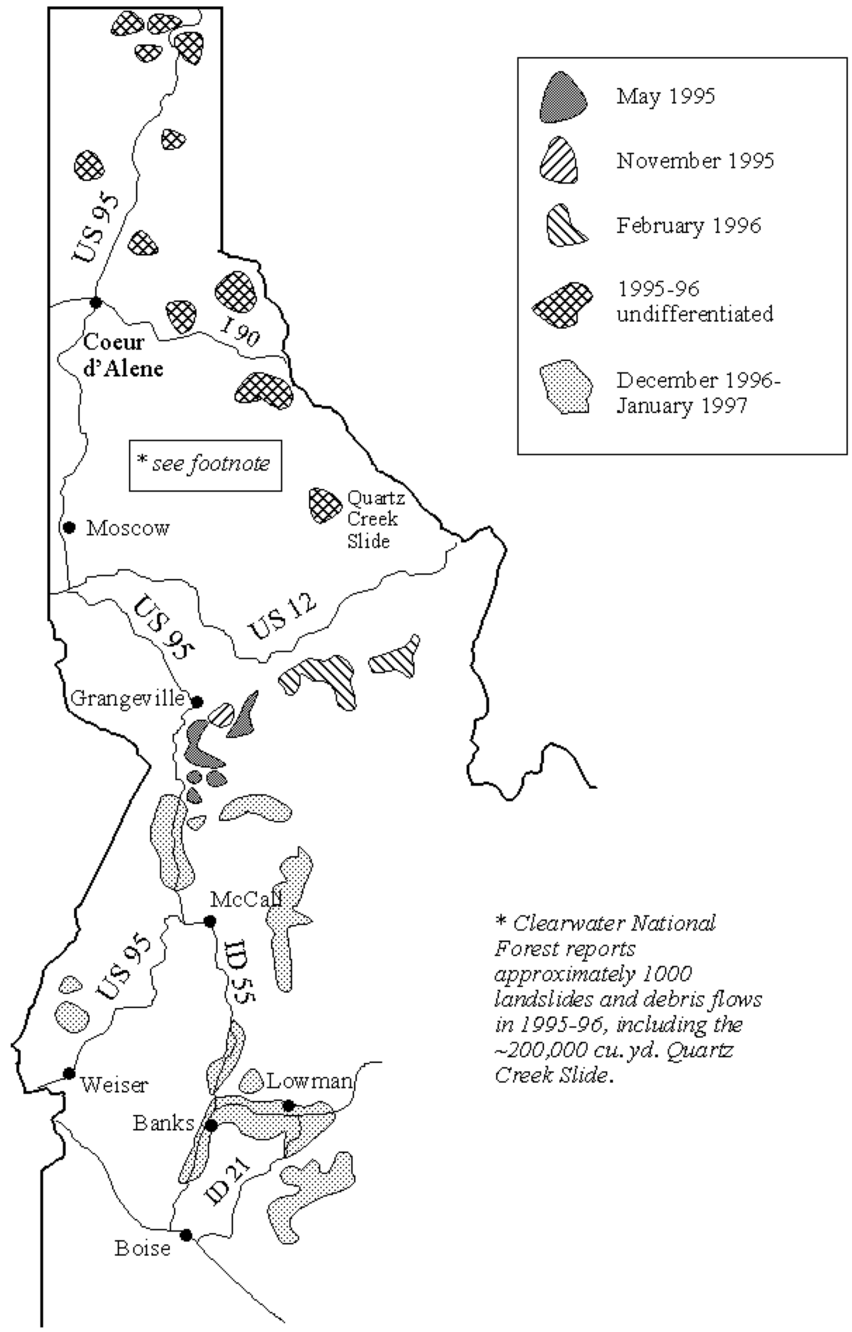
- Assessing the adequacy of the current network of weather stations (especially rain gauges) and stream gauges, to determine if it is adequate for estimating the size of events that trigger landslides and floods.
- Working with the Idaho State Climatologist at the University of Idaho to prepare a rainfall frequency atlas for Idaho
- Conducting a correlation study of rainfall intensity frequency with the landslide database to determine threshold events that trigger landslides.

Recommendation 6: Include scientists (e.g., geologists, hydrologists, engineers, soil scientists, geomorphologists) alongside emergency managers on rapid response teams in events such as the January 1997 storm to provide on-site assessment of continuing risk, types of failures, and short-term mitigation. Encourage organizations and agencies to use MOUs (memoranda of understanding) to formalize agreements to participate in these responses and enable the state to draw upon local expertise in emergency situations.

Recommendation 7: Develop public education and technology transfer to enhance public awareness of landslides and related hazards. This could take many forms, both general and specific, from informative, general-interest brochures to workshops for county officials and emergency response personnel.

TOTAL RAINFALL
DEC. 21, 1996 - JAN. 2, 1997




May 1995
November 1995
February 1996
1995-96 undifferentiated
December 1996-January 1997
US 95
I 90
Coeur d'Alene
* see footnote
Moscow
Quartz Creek Slide
US 12
Grangeville
McCall
ID 55
Weiser
Lowman
Banks
ID 21
Boise
* Clearwater National Forest reports approximately 1000 landslides and debris flows in 1995-96, including the ~200,000 cu. yd. Quartz Creek Slide.

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MITIGATION COMMITTEE REPORT

The main goals of landslide mitigation are to preserve lives, property, and revenue, and to prevent the disruption of critical services and the economy. Impacts of landslides can be mitigated by federal, state, and local governments through implementation of appropriate guidelines, regulations, ordinances, public awareness, and emergency preparedness. The Mitigation Committee charge was to define mitigation strategies and existing models. Particular attention was devoted to existing ordinances and guidelines, design and construction standards, public awareness campaigns, warning systems, and rapid response teams. All of the subjects have been addressed, some in greater detail than others.

Considerable discussion is presented in the report on ordinances and guidelines, public awareness suggestions, early warning systems for weather-related landslide emergencies, actual or potential, and guidelines for assembling technically-oriented rapid response teams. Design and construction standards are set by federal and state code and regulations or are established by professional engineering or geotechnical organizations. Modifications to these standards are most appropriately made through performance feedback to the regulating agency or professional group.

Other mitigation topics presented in the report are: physical mitigation methods for site specific consideration, liability potentials, financial aid options, and cost-benefits of mitigation.

The following recommendations are presented for consideration:

- Implementation of a state-wide landslide hazard mitigation plan that would encourage and support local mitigation efforts.
- Update existing state-wide database and map of landslide and landslide-prone areas. Include a periodic landslide surveillance program.
- Implement guidelines for emergency activation of geotechnically-oriented Rapid Response Team(s).
- Implement avoidance measures for serious landslide-prone areas, where appropriate.
- Implement appropriate ordinances and zoning regulations to prohibit excavations and drainage from contributing to slope instability.
- Implement a landslide hazard public awareness campaign.
- Implement professional practice guidelines for geotechnical evaluation of landslides.
- Recognize that areas damaged by landslides are prone to reoccurrence, erosion, and rockfall.
- Erosion control appears to be the most economic mitigation method, but it is complicated by ownership and funding issues.
- Site safety and hazard plans should be incorporated into all emergency action measures.

I. INTRODUCTION

Landslides are hazards that can be mitigated through avoidance, surveillance, evaluation, regulations, construction, and implementation. The key strategy is implementation of mitigation procedures to reduce the potential problems of impacts to life and property in the State of Idaho.

Landslides are a natural process of the earth's surface, resulting from combined factors of rainfall, gravity, and earthquakes. They are a dynamic form of erosion, the inexorable process that wears down geologically elevated land masses. The most frequent landslide-triggering mechanism is water from intense rainfall or human-introduced sources (Schuster and Krizek, 1978). Although earthquakes also cause a great number of landslides (Keefer, 1984), heavy precipitation is a much more frequent event, and therefore causes more landslides.

Landslides are part of a complex system of geologic interactions. Predicting the location and establishing the probabilities of future landslides is difficult, time-consuming, and expensive. At best, geologists can qualitatively identify zones of possible landslide hazard; however, the quantitative probabilities of landslides at site specific locations within these zones frequently cannot be determined (Nilson and Turner, 1975). Hillside stability of specific sites can only be understood after extensive subsurface exploration. By comparison, flood hazards can be quantitatively determined by generally accepted statistical methods (Dunne and Leopold, 1978).

Landslides become problems when they occur in populated areas and along highway systems. Much of the Idaho highlands are characterized by steep, unstable slopes. Population growth, increasing development of timber and mineral resources, utilization of large tracts of land for recreation, and expansion of urbanization have increased landslide-related losses. These losses will persist into the future.

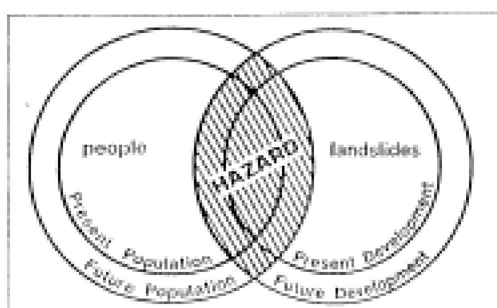

Figure M-1. The relationship of people, landslides, and hazards (from Wold and Jochim, 1989).

II. MITIGATION METHODOLOGY

The main goals of landslide hazard mitigation are to preserve lives, property, and revenue, and to prevent the disruption of critical services and the economy. These goals are accomplished by reducing the frequency of occurrence, the extent and severity of landslides, and by redistributing social and economic impacts when landslides do occur. Three general methods used to accomplish these goals are (Jochim and others, 1988):

- Modification of community vulnerability;
- Modification of the physical system; and
- Modification of the consequences (Jochim and others, 1988).

A. Modification of Community Vulnerability

Reduction of landslide hazards in the United States (Turner and Schuster, 1996) is achieved mainly by:

- Restricting development in landslide-prone areas (avoidance), a function assisted by documentation of landslide susceptibility;
- Requiring that excavation, grading, landscaping, and constructional activities do not contribute to slope instability (ordinances and zoning); and
- Protecting existing development and population by physical control measures, such as drainage, slope stability improvements, erosional control, and protective barriers, or by monitoring (surveillance) and emergency preparedness.

These techniques as discussed by Kockelman (1986) are used individually or in various combinations to reduce or eliminate losses due to existing or potential landslides. The first two methods can be promoted by public legislation. Such legislation is common under the jurisdiction of local governments.

Avoidance

The reference *Reducing Losses from Landsliding in the United States* by the National Research Council's Committee on Ground Failure Hazards written in 1985 discusses avoidance and building codes as follows:

> ***Avoidance** involves eliminating or restricting development in landslide-prone terrain. While total avoidance, i.e., a total prohibition on the use of landslide-prone lands, is not possible, it is feasible to use these lands in a way that minimizes landslide losses. Thus, it is possible to use such land for recreational open spaces, watersheds, agriculture, and other activities for which the loss in the event of a landslide will be small. It is even possible to allow low-intensity physical development in such areas if appropriate precautions are taken. The principal issue (leading to controversy) in programs of avoidance is the lowering of land values associated with designation as a landslide-prone area* (Jochim and others, 1988).

Various methods are available to state, county, and local governments to educate or control the utilization of site specific landslide-prone areas. Some of these methods are briefly discussed below. Precursory tools to insure landslide problems are adequately addressed include geotechnical evaluation of landslide potential, clear definition of the level of geotechnical study completed and loss of life risk potential.

- Public Informational Programs can help to bring landslide information to the attention of the general public.
    - Information can be disseminated through workshops, conferences, newsletters, bulletins, and press releases.
- Public Notices; warning signs in areas that are susceptible to landslides or notices on subdivision or development plans indicating slide-prone areas.
- Public Record Documentation; identify existing tracts of land, private or other, that are known landslides or that may be slide-prone areas.
    - Provides detailed guidance for planners, engineers, and the general public as to the extent and degree of landslide hazards.
    - Can be used to regulate development.
    - Assists in locating and designing structures.
- Assessments against Land Tracts to control or prevent slides or to repair damaged public facilities. The cost could be assessed against the land that will benefit from construction.
- Provide funding source through development costs for recovering public monies used to protect private property.
    - Create incentives for developers to limit activities in landslide-prone areas.
- Financing Policies; lenders and governmental agencies can deny loans for development in identified landslides or slide-prone areas.
    - Discourages financial institutions from providing loans for development in landslide- prone areas.
    - Provides financial institutions with knowledge regarding areas of landslide potential.
- Public Facilities; adopt policies that prohibit financing and constructing public facilities in potentially landslide-prone areas.
    - Public financing for schools, transportation, utilities, sewers, etc. shall not be approved in areas defined as landslide-prone.
- Insurance; require landslide insurance for development in landslide-prone areas to encourage land uses that are less likely to cause or experience damage.

- Disclosure; require a registered geotechnical engineer and/or geologist to perform site evaluations on proposed development areas and tracts of land where zoning ordinance indicates potentially unstable land and present landslide hazard information in reports and maps in nontechnical language. Site evaluations should be performed by qualified, registered professionals with expertise in landslide evaluation and mitigation techniques. Site evaluations are commonly multidisciplinary studies involving specialty fields such as engineering geologists, geotechnical engineers, soil scientists, geomorphologists, etc. Appendix M-1 outlines general fields of professional expertise and defines areas of overlap for registered geologists and engineers. The appendix is intended as an aid for planners, zoning officials, and local authorities in determining the scope of site evaluations under consideration or the adequacy of completed site evaluations. Site evaluations should become public records to be included in the statewide inventory.

Ordinances and Zoning

The purpose of landslide hazard ordinances is to encourage prudent land use of landslide-prone areas for the protection of the health, safety, and property of the citizens of the city or county enacting the ordinance (Christenson, 1987). Some landslide hazards cannot be mitigated or are too costly to mitigate and, therefore, are best avoided. Other landslide-prone areas are easily mitigated and need not influence land use significantly as long as the hazard is identified. Because of this, general landslide hazard information should be utilized in developing local master plans and zoning ordinances so that land use can then take into account landslide hazards.

The first step in addressing landslide hazards is an ordinance to identify hazardous areas. In zoning ordinances and master plans, this is done through local or area-wide mapping prior to adoption. Once the possible existence of a landslide hazard is determined, the ordinance should include a means of requiring geotechnical investigations performed by qualified engineering geologists and engineers to address hazards and recommend appropriate action prior to development. In the final step, reports of these investigations along with recommendations for action to mitigate hazards should be submitted to the governmental entity and reviewed by qualified engineering geologists and engineers (Christenson, 1987).

Design, Building, and Grading Codes are regulatory tools available to local governmental agencies for achieving desired design and building practices. They can be applied to both new construction and pre-existing buildings. In rare cases, such as those involving large offshore structures, the effect of landslides can be considered explicitly as part of the design, and the facility can be built to resist landslide damage. In some cases, existing structures in landslide-prone areas can be modified to be more accommodating to landslide movement. The extent to which this is successful depends on the type of landsliding to which the structure is exposed. Facilities other than buildings (e.g., gas pipelines and water mains) can also be designed to tolerate ground movement. Codes and regulations governing grading and excavation can reduce the likelihood that construction of buildings and highways will increase the degree to which a location is prone to landslides. Various codes that have been developed for federal, state, and local implementation can be used as models for landslide-damage mitigation. A fundamental concern with design and building codes is their enforcement in a uniform and equitable way (Committee on Ground Failure Hazards, 1985).

Statewide Planning/County Zoning

In order for consistent regulations to be developed throughout the State of Idaho, the state should adopt certain design standards that guide state, county, and local officials in establishing appropriate regulations for development in landslide-prone areas.

Statewide Planning

- Provide landslide hazard maps and reports to the public, land use planners, zoning officials, and local authorities identifying known landslides and landslide-prone areas for use in land development.
- Perform landslide hazard zone and control evaluations statewide.
- Perform geologic investigations and economic and cost-benefit analyses.
- Prepare objective work programs and scope of work plans.
- Prescribe standards for surveys, mapping, and engineering reports for landslide-related studies.
- Certify technical accuracy and maintain landslide hazard zone analysis.
- Participate in public educational and informational programs regarding landslide hazard and hazard zone management practices.
- Establish liability, the conditions under which such events occur and are traced to specific actions; refer to the Section on Liability under Modifying the Consequences of Landsliding.

The *Rules Pertaining to the Idaho Forest Practices Act, Title 38, Chapter 13, Idaho Code* (Idaho Department of Lands, 1996) are widely used throughout the state and include requirements for drainage systems, culverts, and geologically stable sites. While these rules do not specifically address landslide or debris flow areas, they represent an existing vehicle which could be readily updated and expanded upon to include these types of geologic hazards.

County Zoning

- Develop zoning ordinances
- Landslide-prone area ordinances
- Hillside development ordinances, including density provisions, soil overlay provisions, guiding principles, and grading regulations
- Abatement districts
- Building codes
- Grading codes
- Site investigative requirements
- Restrictive covenants
- Sanitary system codes
- Geological hazard overlay zones

Identification and Surveillance Program

A local or state-wide data base is required to monitor active, potentially active, inactive and critical landslide-prone areas. This data base could include site specific hazard maps or regional landslide hazard maps with the appropriate accompanying data base. Ideally, these maps would indicate where landslides have occurred in the past, the locations of landslide-susceptible areas and the probability of future occurrences. The landslide data base, including hazard maps, should be readily available to interested state, county and local entities, as well as the general public.

Surveillance programs with periodic monitoring of landslide areas establish a data base for short-term and long-term decision making. An example surveillance program used by the U.S. Bureau of Reclamation to monitor 371 landslides on its project lands and facilities in the seventeen western states is included in Appendix M-2 (USBR, 1997). Instructions on the preparation of the Landslide Register are also included in the appendix.

Emergency Preparedness

Emergency planning and preparation consist of identifying potential problems, determining the required actions and parties responsible for implementing them, and ensuring the readiness of necessary equipment, supplies, and facilities (Jochim and others, 1988). An important aspect of preparation is a public educational and informational campaign informing citizens of their potential exposure to landslide hazards, types of warning to be issued, probable evacuation time available, and appropriate actions to be taken.

Early Warning System. An emergency preparedness system may include the monitoring of conditions, such as snowpack or storm development, with potential for causing a catastrophic event. A landslide warning could involve the following:

> Extensive periods of moderate rain combined with a significant melting snow, or a heavy rainfall in a short period of time (less than an hour) can cause landslides to develop. Other factors such as soil moisture, geological formation, steepness of slopes, roads, and burned terrain contribute to the occurrence of unstable ground. Because of the number of nonmeteorological factors in forecasting landslides, a landslide warning program is beyond the mission of the National Weather Service (NWS). However, the NWS may provide support to the responsible warning agency (Idaho Bureau of Disaster Services or Idaho Geological Survey). This support is notification of the following information:

- Rainfall of 4.0 inches or more is expected/observed on an existing snowpack over a 7-day period.
- Rainfall of 2.0 inches in 24 hours is expected on frozen ground (no snow cover).
- Expected/observed rainfall over burned areas (less than three years rangeland; five years forested areas) of .80 inches an hour or 1.5 inches an hour over nonburned areas.
- The NWS would assist the responsible warning agency in dissemination of the landslide advisory watch, or warning.

Advanced, on-the-ground warning systems are expensive and required detailed analysis. Other requirements for advanced warning systems to be successful would be the correct conditions to allow sufficient reaction time. types of warning systems include check dams with trip wires, ultrasonic detection, pore-pressure monitoring, rain gauges and geophones/ground vibrations (Rick Lattusen, USGS personal communication). implementation of advanced warning systems by the owner should be based on successful cost/benefit analysis. The types of debris flows and landslides that occurred this winter in Idaho do appear to provide sufficient reaction time or cost/benefit ratio to be applicable.

An emergency preparedness system can be an effective tool for protecting inhabitants of landslide hazard areas. However, it is limited in its ability to protect property and facilities at risk (Jochim and others, 1988).

B. Modification of the Physical System

Landslide control and stabilization can dramatically reduce the likelihood of earth movement. The control of drainage in sloping terrain and the building of retaining walls and diversion or storage structures can be used to control landslides and to minimize the damage they do to developments and facilities. The principal difficulty with landslide control is the high cost involved.

Engineering geologic site characterization is probably the most important factor in designing and positioning one or more effective landslide mitigation devices. This characterization allows a determination of whether a slope has a potential for failure, whether the hazard can be mitigated and onto what segment of the slope a proposed mitigation device would be most effectively positioned (Howard and others, 1987).

When designing control measures, it is essential to look well beyond the landslide mass itself. A translational slide may spread over great distances if the bedrock surface is sufficiently inclined and the shear resistance along the surface remains lower than the driving force. Debris flows can frequently be better controlled if mitigation efforts concentrate on stabilizing the source area. An understanding of the geological processes and the surface and ground-water regimes, under both natural and human-imposed conditions, is essential to any mitigation planning (Jochim and others, 1988).

Some factors that determine the choice of physical mitigation are:

- Type of movement (e.g., fall, slide, avalanche, flow);
- Kinds of materials involved (rock, soil, debris);
- Size, location, depth of failure;
- Process that initiated movement;
- People, place(s) or thing(s) affected by failure;
- Potential for enlargement [certain types of failures (e.g., debris flows, translational slides) will enlarge during excavation];
- Availability of resources (funding, labor force, materials);
- Accessibility and space available for physical mitigation;
- Danger to people; and
- Property ownership and liability.

The physical mitigation of landslides usually consists of a combination of methods. Drainage is used most often; slope modification by cut and fill and/or buttresses is the second most often used method. These are also, in general, the least expensive methods.

The various types of physical mitigation methods are listed in Table M-1. Descriptions of these methods are provided in Appendix M-3.

TABLE M-1. PHYSICAL MITIGATION METHODS (from Jochim and others, 1988).

APPLICATION	METHOD
Physical Mitigation Methods for Slides and Slumps	
Surface Drainage	Ditches, Regrading, Surface sealing
Subsurface Drainage	Horizontal drains,vertical drains/wells, trench drains/interceptors, cut-off drains/counterforts, drainage galleries or tunnels, blanket drains, electro-osmosis, blasting, subsurface barriers
Excavation or regrading of the slope	Total removal of landslide mass, Regrading of the slope, Excavation to unload the upper part of the landslide, Excavation and replacement of the toe of the landslide with other materials
Restraining structures	Retaining walls, Piles, Buttresses and counterweight fills, Tie rods and anchors, Rock bolts/anchors/dowels
Vegetation	Seeding, Planting
Soil hardening	Chemical treatment, Freezing, Thermal treatment, Grouting
Physical Mitigation Methods for Debris Flows and Debris Avalanches	
Source-area stabilization	Check dams, Revegetation
Energy dissipation and flow control	Check dams, Deflection walls, Debris basins, Debris fences, Deflection dams, Channelization
Direct protection	Impact spreading walls, Stem walls, Vegetational barriers
Physical Mitigation Methods for Rockfalls	
Stabilization	Excavation, Benching, Scaling and trimming, Rock, Anchored mesh nets, Shotcrete, Buttresses, Drainage, Dentition
Protection	Rock-trap ditches, Catch nets and fences, Catch walls, Rock sheds or tunnels

Enhancement of Design and Construction Standards and Specifications

One of the charges initially given to the Mitigation Committee was to enhance design and construction standards and specifications for infrastructure located in debris flow areas. A review showed that design and construction standards and specifications are set by federal and state code and regulations or are standard practices established by the engineering profession. Enhancements to these standards and specifications are best made through performance feedback to regulating agencies and engineering societies or technical groups from working professionals in the field.

As an example of this process, a number of culvert failures occurred in response to debris flows triggered by the December 1996/January 1997 event. A review by Idaho Transportation Department staff showed that it was not feasible to modify construction standards or requirements for culvert sizes using hydrology principles. These hydrologic principles are based on soil type and drainage area which did not change during the storm event. The critical factor in the culvert failures was a change in the bedload, including woody debris, in the debris flow/landslide regime. Active or potentially active landslide and debris flow areas should be mapped and re-evaluated for size based on the new bed load. Recommendations for improved design standards include:

- Double the pipe capacity required for hydraulic reasons due to inefficiency with boulders and other debris present in the bedload (using the next higher size pipe approximately doubles capacity).
- Utilize headwalls with trash racks to prevent blockage.
- Provide a maintenance road for machine access to clear debris.
- Provide additional drainage, such as blanket drains, french drains, and seepage collection, to increase stability and prevent piping failures.

C. Modification of the Consequences

Modification of the consequences of landsliding involves assisting individuals and communities in preparing to survive and recover from hazard occurrences. This includes rapid-response team evaluation, determining liability, increasing public awareness by information dissemination and disclosure, and redistributing economic losses over time and among a larger segment of society through insurance. Insurance, tax adjustments, assessment districts, and tort liability are explained in greater detail in Appendix M-4.

Landslide/Debris Flow Rapid Response Team

The aftermath of a landslide or debris flow event can have devastating effects that disrupt communications and transportation systems and often isolate local communities. One method to mitigate the consequences of landslides is to deploy technically-oriented rapid response teams to provide onsite assistance to state and county authorities, public utilities, impacted landowners, and the public during the emergency. The rapid response team would consist of qualified professionals with expertise in landslide processes and mitigation methods and could include geologists, engineering geologists, geotechnical engineers, hydrologists, soil scientists, and geomorphologists. The rapid response team would determine the type and cause of the landslide, work with state and county authorities, public utilities, and property owners to determine the effect and extent of damage, and assess the risk from continuing movement and the potential for development of additional landslides.

The Mitigation Committee has identified a number of federal, state, and county agencies and other entities (listed below) that may have staff expertise that could be used in rapid response teams. Team members would be selected on the basis of their knowledge, expertise, and practical experience in landslides and mitigation, their willingness to participate in the rapid response program, and their employers' willingness to make their staff available. Implementation of the rapid response program would require the development of memoranda of understanding (MOU's) or memoranda of agreement (MOA's) with the participating parties to delineate the responsibilities of the participants and to arrange funding. Draft agreements that could be used to develop these memoranda are included in Appendix M-5 of this report. Participating entities would also need to designate a point of contact for notification of the emergency and develop a list of qualified staff members participating in the rapid response program.

Deployment of a rapid response team could be accomplished through the following process:

Notification of landslide affecting life, property, human services, environment by county officials, sheriff, and/or state police to the Idaho Bureau of Disaster Services.

Bureau of Disaster Services determines extent of damage or imminent danger or future threat to:

- Life
- Transportation routes
- Water, public, streams/rivers
- Human services, power, telephone, natural gas, dams, structures, life property
- Extent of landslide

Bureau of Disaster Services:

- Evaluates and prioritizes landslide
- Determines route of access by land or air
- Provides means of direct communication with Rapid Response Field Team
- Dispatches Rapid Response Team

Rapid Response Teams identified from:

State and Other Agencies
- Idaho Department of Fish and Game
- Idaho Department of Lands
- Idaho Department of Transportation
- Idaho Department of Water Resources
- Idaho Division of Environmental Quality
- Idaho Geological Survey
- State Universities
- County Officials
- Association of General Contractors

Federal Agencies
- U.S. Army Corps of Engineers
- U.S. Bureau of Land Management
- U.S. Bureau of Reclamation
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Geological Survey
- U.S. National Marine Fisheries Service
- U.S. National Weather Service
- U.S. Natural Resources Conservation Service

Bureau of Disaster Services will brief team members and provide team assignments.

Rapid Response Team will gain access to the landslide area and evaluate the landslide complex for:

- Type of slide complex and cause
- Determine category of Slide (I, II, III, IV, etc.)
- Determine effects and damage to
    - Loss of life
    - Transportation routes, bridges, railroads
    - Property (private, crops, forest, etc.)
    - Flooding caused by damming effect or irrigation systems
    - Effects of sedimentation to waterways
    - Facilities containing hazardous chemicals or waste
    - Utilities (sewer, water, power, natural/liquid gas, telephone)
    - Ground surface and structural dislocation
    - Burial of structures
    - Potential for reoccurrence
    - Potential for further damage during mitigation actions

Rapid Response Team reports back to Bureau of Disaster Services for response priority and recommends actions to mitigate and provide for protection of life, health, property, and safety in order to:

- Minimize property damage and disruption of community activities and services to the degree practicable.
- Re-establish critical facilities and services
- Secure the site for safety purposes and provide relief to disaster victims
    - Remain onsite to supervise mitigative action
    - Report other emergency actions that may be pending
    - Respond to other landslide reports
    - Return to home base and await further instruction
    - Evaluate for continued or further hazard

Additional Comments:

- Teams will need emergency response training of some type.
- Job descriptions will need to be modified for positions identified as rapid-response persons, working in extremely hazardous conditions.
- Teams should be protected from liability due to emergency actions.
- Teams should be empowered to disburse emergency contracts for supplies and equipment to perform emergency actions.

Liability

The consequences of landslide events on individuals and governments can include liability for losses generated by these events. Thus, homeowners, builders, developers, architects, engineers, governmental entities, and many others are threatened with increased liability. The threat of litigation may act as a deterrent to poor quality geologic or engineering reports, improper design, poor construction, improper grading, faulty hillside maintenance practices, and governmental approval of plans for development of hazardous sites (Jochim and others, 1988).

Establishing liability is the legal means developed by society to recover damages, such as bodily injury, medical expenses, death, emotional stress, and economic loss, resulting from the improper activities of another.

Sutter and Hecht (1974) (in Jochim and others, 1988), supplemented by McGuire (1985) (no reference listed in Jochim and others, 1988), list six types of lawsuits that are brought by injured parties against those responsible for their losses:

- Fraud: a former owner purposely advises a purchaser that the house is in perfect condition, when in fact cracks caused by recent ground failure have been disguised by repair and fresh paint.

- Negligence: an owner changes the natural drainage of his land causing a landslide on adjacent property.

- Strict Liability: a developer and seller of lots improperly cuts, fills, and/or compacts earth to create a building site.

- Breach of Warranty: parties to a real estate sale agreement insert false guarantee of soil and geologic stability.

- Failure to Comply with Regulations: a developer or subdivider fails to perform the geologic investigations required by state statute or local ordinance, or fails to carry out recommendations.

- Public Negligence: a city grading or building inspector fails to perform periodic inspections of lot grading building construction to ensure that the work complies with the municipal code.

- Professional negligence: an engineer/geologist fails to recognize a hazard or to follow good practice, makes an error, or omits vital data.

As people settle and develop in closer proximity to existing or potential landslide areas, the premise that a hazard is an “Act of God” is becoming unacceptable as a defense against liability. As our understanding of natural processes and disasters increases, the conditions under which such events occur are more easily traced to specific actions and actors. The work of the Association of Bay Area Governments (1984) on the liability of businesses and industries for earthquake hazards and losses is applicable to landslides, particularly those triggered by seismic events. The Association concludes that the legal defense that an earthquake is an “Act of God”, may only work in two very limited situations where the event:

- Was of such type or size as to be unforeseeable and the business did not act negligently with respect to dealing with a foreseeable event; and

- Was foreseeable, and the defendant took all reasonable actions to prevent harm, but nonetheless damage still occurred.

According to Tank (1983), “Recent court decisions have identified the developer or his consultants as primarily responsible for damage due to land failure.”

The overall consequences of these decisions to individuals, professionals, and governments are illustrated by a recent earthmoving damage case. In this case, “The California Court of Appeals First District...has held that is the duty of a real-estate broker selling a house to conduct a reasonably competent and diligent inspection of the property and disclose to the buyer any defects revealed by the inspection” (Kockelman, 1986, p. 38).

In view of the many elements of society that can be held liable following a landslide, it is logical that this liability be perceived as a significant threat and serve as an incentive to take mitigative action. As the public becomes more aware of the landslide hazard and the resulting consequences, the chances are increased that individuals and governments will take positive action to prevent excessive exposure to liability.

Public Awareness

Most important in instituting an active mitigation program is the heightening of public awareness about the problem. There is an inconsistency of information and hazard awareness among the public and in local governments across the state. Many people are unaware that they live where natural disasters could destroy or damage their homes. Many local governments are unaware that landslides threaten roads, bridges, utilities, and buildings. In addition, few, if any, legal and statutory mechanisms guarantee the transmission of known hazard information to prospective buyers, and even if owners have access to hazard information, renters are not necessarily informed of a hazard threatening their lives and personal property. Compounding the problem, land-use planning and building-permit agencies serving the public do not always act upon such information even when they have it. Furthermore, it is unlikely that cities or counties will be found liable for landslide damages that result from planning decisions, as long as they make those decisions taking all available information into account. Finally, even if the information is gathered, made understandable to the lay person, and disseminated to the community, citizens may not incorporate the information into their actions (Olshansky and Rogers, 1987).

However, information about landsliding as a hazard becomes a powerful determinant of the choice of means to mitigate landslide impacts. Private lending and insurance have been identified as two important means of impact modification (Olshansky and Rogers, 1987).

Public Awareness Program

A planned Public Awareness Program is important to inform federal, state, county, local, and private entities and the general public on the complexities of potential hazards associated with landslides. Awareness campaigns could be held periodically on a local or state level to:

- Educate the public on the causes and dangers of landslides,

- Educate city council members, county commissioners, or others on the causes, dangers, and both physical and non-physical mitigation techniques for addressing landslide problems.

A multi-agency committee including members of the media, with the Idaho Bureau of Disaster Services as the lead agency, could be formed to develop a campaign for the public. A separate campaign could be developed for the city council members and county commissioners. This committee could work with the task force committees to develop the content and agenda. Some of the activities of the public awareness campaign could include:

Awareness Campaign for the Public

- Designate a day, week, etc., for the awareness campaign.
  - The Governor signs a proclamation.

- Develop several single-page sheets that would contain landslide information. Some of the topics could include:
  - Dangers of landslides
  - How landslides form
  - Is my property susceptible to landslides?
  - Where are the landslide-prone areas?

- Develop a landslide teaching guide for children and distribute these guides through the schools.

- Develop news releases and several Public Service Announcements (PSA s).

- Hold a landslide conference.

- Select a spokesperson to make guest appearances on morning, noon, and evening television and radio news shows.

- Develop newspaper articles and ensure dissemination of these articles in all weekly and daily newspapers.

- Develop a booth display at major fairs and festivals.

Awareness Campaign for County Commissioners and City Council Members

- Develop an intensive “hands-on” workshop that could cover the causes, mitigation techniques, and dangers of landslides.

- Hold workshops in counties affected by landslides.

- Counties and city councils could develop local zoning laws from workshop information.

Financial Aid

Federal and State Financial Assistance

Kockelman (1986, p. 37) states:

> *Federal and state programs that provide grants, loans, loan guarantees, tax credits, tax deductions, depreciation allowances, insurance, revenue sharing, or other financial assistance have a tremendous effect on public and private development. Obviously, the enabling legislation for these programs can by amended by the U.S. Congress or state legislatures to provide for site investigations in landslide areas, avoidance of hazardous areas, or stabilization of slopes.*

Less popular among elected officials, but equally effective are financial disincentives which act as deterrents to the use and development of hazardous areas. A disincentive could reduce the federal share of a grant if the facility to be funded were to be located in a landslide area. For example, the U.S. Congress . . . introduced provisions into the Flood Disaster Protection Act of 1973 for withholding federal benefits from flood-prone communities that chose not to participate in the National Flood Insurance Program. In providing loans and grants for disaster recovery, the U.S. Congress . . . requires local and state governments to evaluate and mitigate hazards.

Landslide Mitigation as a Condition of Disaster Aid

Nationally, landslide damage costs governments hundreds of millions of dollars per year. Governments pay for disasters through direct assistance, tax deductions for property losses, and low-cost loans for recovery. Over the years, the state and federal government shares of all post-disaster recovery costs have risen sharply. The Colorado Disaster Act of 1973 and the Federal Disaster Relief Act of 1974 (Public Law 93-288) address this increasing burden by attaching hazard-reduction conditions to disaster aid. Section 406 of Public Law 93-288 was enacted in 1974 to encourage identification, evaluation, and mitigation of hazards at all levels of government. The requirements of Section 406 are triggered by a major disaster or emergency declared by the President and apply to all types of declared emergencies and disasters. A hazard mitigation clause is incorporated into the Federal Emergency Management Agency (FEMA)/state agreement for disaster assistance, thereby establishing the identification of hazards and the evaluation of hazard mitigation opportunities as a condition for receiving federal assistance.

FEMA is responsible for administering the Section 406 requirements and has prepared implementing regulations (44 CFR 205, Subpart M) that spell out federal, state, and local responsibilities under Section 406. Under the regulation, a state hazard mitigation coordinator is designated by a governor’s authorized representative to prepare a hazard-mitigation plan and to ensure its implementation. The state may establish a group of individuals from state and local agencies to assist in preparing the 406 plan, which must be completed and submitted to FEMA within 180 days after the Presidential disaster or emergency declaration (FEMA, 1986).

III. THE COST-BENEFIT OF MITIGATION

A. Cost of Landslides

The Committee on Ground Failure Hazards (1985) estimates that economic losses of at least $1 to $2 billion and 25 to 50 deaths occur each year in the United States as a result of landsliding. Economic losses include direct and indirect costs. Schuster and Fleming (1986) define direct costs as “the costs of replacement, repair, or maintenance due to damage to installations or property within the boundaries of the responsible landslide.” They list indirect costs as:

- Reduced real-estate values in areas threatened by landslides;
- Loss of productivity of agricultural or forest lands;
- Loss of agricultural or industrial productivity as a result of damage to land or facilities or interruption of transportation systems.
- Loss of tax revenues on properties devalued as a result of landslides;
- Costs of measures to prevent or mitigate additional landslide damage;
- Adverse effects on water quality in streams and irrigation facilities outside the landslide limits;

- Secondary physical effects, such as landslide-caused flooding, for which the costs are both direct and indirect; and
- Loss of human productivity due to injury or death.

In addition, there are intangible costs such as stress, reduced quality of life, and the destruction of personal possessions with only sentimental value. Because costs of indirect and intangible losses are difficult or impossible to calculate, they are often undervalued or ignored.

The rising event-specific and cumulative costs of landsliding are a direct consequence of the increasing vulnerability of populations to the hazard. In most regions, the overall rate of occurrence and severity of naturally-caused landslides has not increased. What has increased is the extent of human occupation of marginal lands and the impact of human activities on the environment. Increasingly, hazard-mitigation techniques are being used to overcome objections to development of marginal land.

When extensive development of marginal or potentially hazardous land is proposed, a cost-benefit analysis should be performed to determine if mitigation is justifiable and cost effective. Frequently, when an accounting is made of the potential costs and benefits of development in a hazardous area, the costs may outweigh the benefits over the long term. The cost of mitigation should be considerably less than, or at least equal to, the total value of the property to be protected. However, in cases of existing development, where human lives are threatened, strict economic considerations may have to be ignored.

Petak and Atkisson (1982) use “break-even” damage rates to identify projects where mitigation might be considered feasible. They list the following five values as necessary for determination of the break-even rate:

- The initial cost of the mitigation;
- The annual expected loss reduction associated with the mitigation;
- The period of time over which costs are to be amortized and loss reductions are to be experienced;
- The total estimated loss reduction that will be produced by the mitigation over the lifetimes of buildings on areas to which the mitigation is applied; and
- Either the discount rate that is applied to building-life loss reductions, or the building life accumulated annual amortized costs of the mitigation at a specified interest rate.

B. Economic Payoffs from Landslide Hazard Mitigation

Studies have been conducted to estimate the potential savings when measures to minimize the effects of landsliding are applied. One early study by Alfors, Burnett, and Gay (1973) attempted to forecast the potential costs of landslide hazards in California for the period 1970-2000 and the effects of applying mitigation measures. Under the conditions of applying all feasible measures at state-of-the-art (for the 1970's) levels, there was a 90 percent reduction in losses for a benefit/cost ratio of 8.7:1 or $8.7 saved for every $1 spent. Other studies by Leighton (1976) have shown higher ratios. The benefit/cost ratio becomes better as the property becomes more hazardous and/or the density of the threatened population/structures becomes greater.

Cost-Benefit Analysis. This method is used by engineers, economists, and planners to evaluate the feasibility of urban drainage and flood control projects, but can be used equally well for any contemplated project using structural methods. A cost-benefit analysis enables engineers and/or planners to make rational choices among structural alternatives by determining whether, over the life

of a structure, the value of the property and/or lives and/or services protected is equal to or greater than the cost of the structure.
First, objectives must be determined. Examples of objectives are to:

- Reduce damage and maintenance requirements to public and
- private property and facilities;
- Enhance the value of land and other property in the area;
- Reduce threat to life;
- Reduce public inconvenience;
- Reduce traffic hazards;
- Enhance emergency vehicle movement.

A benefit is provided when any one of the objectives is met. Benefits are usually classified as tangible or intangible depending on the extent to which they can be measured in monetary units.

Since it is difficult or impossible to quantify intangible benefits and even many of the tangible benefits, it is recommended that the tangible benefits quantified for landslides include mainly 1) minimization of property damage; 2) minimization of maintenance costs; and 3) preservation of life (lawsuits have been filed and won in wrongful-death cases on the basis of potential lifetime earnings).

For more information on how to prepare a cost-benefit analysis, see *Feasibility Evaluation: Methodology for Evaluation of Feasibility* by the Urban Drainage and Food Control District Report (1977).

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POLICY COMMITTEE REPORT

Two decades of drought have compounded the issue of landslide and debris flow, letting many Idaho natives forget and never initiating newcomers into the natural hazards of our landforms. Consequently we have neglected infrastructure, neglected contingency funding, and neglected the essential functions of government to protect citizens through land-use planning.

Because of this neglect, many of the policy recommendations to implement the mitigation recommendations of this report involve expenditures of money. In a climate of fiscal conservatism, such recommendations cannot be popular. Yet the costs of the disasters of 1996 and 1997 should remind Idahoans that prevention is cheaper than response and recovery, and a truly frugal policy will reduce certain future losses by judicious use of present dollars.

Policy recommendations are for state and for local implementation. Many state recommendations involve providing funds through either executive direction to agencies or legislative action. While measures that require money outlays are not popular, the Task Force Policy Committee believes that it is essential to identify them so that the implications of their implementation on fiscal policy can be weighed against the need of government to act to protect its citizenry.

Possible sources for funding these programs include fuel tax (when transportation infrastructure is benefited), a surcharge on insurance policies (when reduction of rates is a potential result), and general fund appropriations, since reduced losses benefit all citizens.

Policy Recommendations:

1. Through appropriation provide one-time funding for the Bureau of Disaster Services, Idaho Department of Water Resources, Division of Environmental Quality, and the State Emergency Response Commission to jointly develop a statewide flood prevention plan that includes the recommendations of the 1996 Interagency Hazard Mitigation Team report on the north Idaho flooding disaster and the 1997 Interagency Hazard Mitigation Team report on the flood/landslide/winter storm disaster.

   Although the recommendations in these reports include watershed management, floodplain management, and education/awareness, they point to a comprehensive approach to watershed management that is essential to mitigating landslides and managing development in sensitive areas.

   Timeframe for completion: 2 years

2. Through appropriation provide one-time funding for IDWR to evaluate existing hydrological monitoring networks for adequacy of both data reporting and warning capability and to recommend expanded networks where needed, including use by emergency response agencies.

   Collection of hydrologic data assists in assessing trends that can lead to danger on both a long-term and short-term basis. For communities located in hazard areas, monitoring instruments can also provide emergency warning.

   Timeframe for completion: 6 months

3. Through appropriation provide funding for a grant program to assist counties in identifying transportation routes, infrastructure, and structures at high risk and install warning systems if appropriate.

   Timeframe for initializing program: 6 months

4. Through executive order require participation in the National Flood Insurance Program as a condition for receiving state relief for repair of damaged structures.

   Damage from debris flows is a covered hazard under flood insurance provided by the National Flood Insurance Program, but unless local jurisdiction participate in the program, individuals are unable to purchase the insurance.

   Timeframe for completion: 2 months

5. Through appropriation, provide funding to Idaho Department of Lands to lead an interagency team including the Idaho Transportation Department, Idaho Geological Survey, Idaho Department of Water Resources, the U. S. Bureau of Land Management, U. S. Bureau of Reclamation, and the U. S. Forest Service to inventory slope failures and identify problem areas and to expand current mapping to include a GIS-based overlay that identifies active slides and potential problem areas.

   Many agencies ,both state and federal, have information about landslides, but it is not currently compiled and comprehensively mapped to provide a useful resource for mitigation planning.

   Timeframe for completion: 2 years for initial mapping, maintenance thereafter

6. Through appropriation provide funding for a grant program to assist counties in installing debris retainage or collection systems.

   Timeframe for initiation of program: 4 years

7. Direct by executive action that the Attorney General take appropriate measures to ensure compliance with the Local Land Use Planning Act of 1975 (Idaho Code 67-65), specifically that local jurisdictions include event histories and the results of geological/geotechnical studies in land-use planning for new development.

   Unless land-use planning incorporates scientific knowledge and historical records of hazard events in its process, decisions affecting lives and capital expenditures cannot balance risk with desired human activity.

   Timeframe for completion: 3 months

8. Expand current legislation relating to disclosure of pr-existing conditions in real estate transactions to apply to new developments and to make noncompliance subject to prosecution and fine.

   Since many new buyers assume that local government assures public safety through building inspection and land-use planning, they do not expect homes to be built without building codes or on unsafe locations. Disclosure statements provide buyer protection from such assumptions and may protect local jurisdictions from assuming liability for individual losses.

Timeframe for completion: next legislative session

9. Amend Idaho Code to require that local highway jurisdictions adopt uniform design standards for bridges and culverts and other waterways, such as low-water crossings, as a condition for receiving state assistance.

   Timeframe for completion: next legislative session

10. Authorize, by executive action, the use of more conservative event frequencies for design criteria for bridges and culverts.

    Current standards in use by Idaho Transportation Department are set by federal regulation, but are minimum standards. Application of more conservative design standards may be appropriate in higher-risk areas.

    Timeframe for completion: 2 years

11. Assist local jurisdictions in funding inspectors for managing of development on hazardous and sensitive areas, to be funded by a statewide surcharge on building permits.

    Timeframe for completion: 2 years

12. Through appropriation provide one-time funding to the Bureau of Disaster Services to lead an interagency team to develop guidelines for local jurisdictions regarding development on alluvial fans and for minimum setbacks for sensitive or high-hazard areas.

    Awareness of hazards is only one aspect of mitigation. When land use is constrained, individuals need assistance in selecting appropriate locations and construction techniques to reduce risk. Such guidelines would assist jurisdictions in applying realistic and consistent standards.

    Timeframe for completion: 2 years

13. Through appropriation provide funding to assist counties in preparing mitigation plans that identify risks and strategies for reducing their impact.

    Existing federal programs support this process but as a grant requiring a local match. Planning workshops and assistance could enable smaller jurisdictions to address mitigation without compromising other important services.

    Timeframe for completion: 5 years

14. Authorize development of an interagency agreement to supply technical personnel to provide assistance and information on emergency response.

    Jurisdictions often lack basic expertise in assessing the causes and consequences of landslides and debris flows, while public safety issues may require swift decisions. A technical team to provide such expertise in such a timeframe would need to be established with interagency agreements, exercised with procedures, and provided for funding.

Timeframe for completion: 2 years

15. Through appropriation provide one-time funding to the Local Highway Technical Assistance Council to develop maintenance criteria to assist counties in creating priority road systems.

    Unless counties have defined a system of roads that have priority for maintenance and repair, they will be impoverished by demands to cope with landslides on all roads in their jurisdiction. Having a priority road system will also assist in budgeting for maintenance and repair and will also assist expeditious repair for federally-declared disasters.

    Timeframe for completion: 2 years

FUNDING COMMITTEE REPORT

The following paper has been prepared to discuss the funding needs, resources and processes both as they relate to Idaho s widespread landslide occurrences during December 1996 through January 1997 and as they would further relate to future landslide preparatory and recovery activities in the state.

I. INTRODUCTION

The state's needs in terms of landslide preparatory and recovery activities are extensive and, with respect to the former, virtually unlimited. Conversely, the extent of resources available to the state to address these needs are quite limited due to the level of funds available, the qualification limitations associated with such funds and the competition with other needs for these funds.

In consideration of the Idaho's current and future needs and the above noted funding limitations, the objectives for this paper are to:

1. Describe the types of landslide needs confronting the state.

2. Identify potential resources available to the state to address its landslide needs.

3. Offer recommendations and guidance concerning (a) Strategies to consider for making best use of existing funds and resources (b) Potential funding and resource gaps.

II. IDAHO'S LANDSLIDE NEEDS

When they occur, landslides present the state with the need for immediate corrective actions. In addition, the risk for future landslides presents the state with the need for less immediate though equally important mitigation actions. In consideration of the above, this section will examine the issue of landslide needs in terms of the time frame within which the various needs become important and the scope of impact associated with these needs.

The time frame structuring used to describe the state's landslide needs is as follows:

1. Immediate Needs Specific sites already impacted by slides and/or for which, under reasonably expected meteorological conditions, there exists an imminent risk of significant further impact.

2. Midterm Needs Areas recognized for their demonstrated potential for landslides but which, under typical meteorological conditions, do not possess an imminent risk for significant impact.

3. Long-term NeedsRegions or corridors possessing the necessary characteristics to make them potentially susceptible to impacts under extreme and nontypical meteorological conditions.

An overview of potential activities to be included under the above three needs strata is as follows:

A. Immediate Needs

Immediate needs typically consist of emergency repairs necessary to restore property and services in the aftermath of a landslide event. Examples of such needs include:

- Removal of debris from roadways, waterways and property.
- Restoration of the roadway prism (embankments, cut slopes, ditches) and structures (bridges and tunnels).
- Restoration of roadway pavement, drainage and appurtenances (signs and guardrail).
- Restoration of waterway channels.
- Restoration of utility services.

Immediate needs could also, in some instances, include preparatory measures to reduce the impact of an imminent landslide threat. Examples of this latter type of need include:

- Slide removal.
- Slide stabilization (counter balancing or buttressing)
- Drainage improvements for water retention, detention or diversion.
- Debris retention measures including rockfall barriers and debris racks.
- Avoidance measures including evacuation of people and rerouting of services.

B. Mid-term Needs

Midterm needs include the identification of areas having a significant potential for future land slide risks and the implementation of measures to reduce such risks and/or their resultant impacts. Typical midterm needs might include:

- Field surveys.
- Permanent slope stabilization measures such as revegetation.
- Drainage improvements (slope contouring, detention basins, culvert replacements, and debris racks).
- Rockfall control measures including reshaping, scaling or stabilization of rock slopes and installation of rockfall barriers and netting.
- Avoidance measures including permanent relocation of homes and realignment of roads and utilities.

C. Long-term Needs

Long-term needs include the identification of landslide risks on a regional or corridor wide scale and the development of policies and recommendations supporting the control of existing landslide conditions and the avoidance of future conflicts with potential landslide risks. Typical long-term needs might include:

- Regional and corridor wide slide risk analysis and delineation studies.
- Development of land use policies and guidance concerning land use in high risk slide areas.
- Development of standards, restrictions and guidance for roadways, logging, waterways and utilities in high-risk landslide areas.
- Development and implementation of advance warning systems to notify state and local officials as well as the general public of conditions posing significant landslide risks.

III. RESOURCES

As noted in the introduction, one of the three objectives of this report is to identify potential resources available to the state to address its landslide needs. The types of resources include funding; donated materials, labor and equipment; and technical assistance, data and support. These resources are typically provided by the public sector through local, state and federal government agencies and institutions, however, some may also be provided through private donations and public/private partnerships.

A. General Overview

A general overview of the types and sources of resources available to address the state's landslide needs is outlined below. In reviewing this information it should be recognized that while there are programs and resources available which can be applied to landslide needs, there are no programs or resources designed solely or specifically for this purpose.

Local Governments

At the local level in Idaho, resources to address landslide needs would typically come from city, town and county governments and highway districts. The type and amount of available resources will depend on the size of the government operations with smaller programs having less people, equipment, materials and funds at their disposal and larger programs having more. Specialized technical expertise will also vary among local governments and agencies but will be more dependent on the experience and technical background of the individuals than on the program size or population base of the government entity.

State Governments and Institutions

At the state level, with its larger population, program and revenue base, there exists a broader and more extensive reservoir of resources in terms of people, equipment, materials, funds and technical expertise. The single most extensive source of such resources at this level would be the Idaho Transportation Department (ITD) with its revenue base (state motor fuel tax); labor, equipment and materials resources; and staff of engineering and contracting specialists.

A second state entity available to assist in addressing the state's landslide needs is the Bureau of Disaster Services (BDS). In its role as the state's emergency management coordinator, the BDS serves to link local, state and federal activities in the state for disaster mitigation and recovery. While the BDS has quite limited resources when compared to ITD in terms of funding, people, equipment, materials and technical expertise, it does have an important support function in securing and overseeing federal funds in cooperation with the Federal Emergency Management Administration (FEMA).
A third state entity available to assist in addressing the state's landslide needs from a technical assistance standpoint is the Idaho Geological Survey. In particular, the IGS has extensive data which it can make available for landslide purposes.

A fourth state entity available to offer technical assistance, particular in the area of long range studies of landslide issues, is the University of Idaho. The University's strength in this regard is its landslide technical expertise, however, the availability of this resource is limited by the need for funding to support such study activities.

Federal Agencies and Institutions

Potentially the broadest and most extensive source of assistance available to the state to address landslide needs is through a variety of federal programs and agencies. The federal government's greatest strength in this regard is its extensive funding resources which it can provide both through ongoing infrastructure programs such as those of the Federal Highway Administration (FHWA) and through special grants and other emergency assistance programs such as those of the Federal Emergency Management Administration (FEMA). In addition, the federal government has available a significant resource base of technical assistance through its numerous resource and program agencies under the Departments of Agriculture, Commerce, Transportation and Interior.

Generally speaking, the least available resource type of those described in conjunction with the state's land slide needs would be the availability of people, equipment and materials. This general statement reflects the perspective that many of the federal program activities are administrative, technical or scientific in nature and are therefore not supported by an extensive labor force or equipment and materials base. Furthermore, even for those federal agencies which do have labor, equipment and materials resources, the jurisdictional limitations on where these agencies can apply such resources will constrain the actual availability of such resources to the state.

Private and Quasi-Private Sources

In addition to the previously mentioned public entities, there also exist some private and quasi-private sources of support to address the state'[s landslide needs. One such example is the assistance provided by private individuals and organizations in conjunction with the Boise Foothills fire recovery efforts of this past year. Another cited example was the cooperative effort between the Potlatch Corporation and the U.S. Forest Service to investigate landslide issues in the Clearwater National Forest. Another possible source to consider for assistance in dealing with the state's landslide needs is the public utilities and most notably the telephone and power companies.

B. Federal Assistance: Background

In considering how best to offer assistance to the state with respect to the issue of landslide funding and resources, it was resolved that it would be most helpful to focus the discussion on the availability of federal assistance. The reasons for this focus include the substantial assistance potentially available from the federal government and the limited knowledge that the state would likely have concerning programs and processes through which these resources are secured.

As a first quick glimpse at the subject of federal assistance, reference should be made to a related document prepared by Oregon Emergency Management and entitled, “Federal Resource Directory: State of Oregon”. As noted in the directory, it was developed to facilitate identification of the appropriate funding agency for implementing mitigation assistance and long term disaster recovery.

Limitations to the aforementioned directory include the facts that it was developed for Oregon and, therefore, may include programs and/or contacts which would not be applicable to Idaho, and that it was developed to address a wide range of disaster needs and therefore includes numerous programs for which landslide work would not be eligible.
Irrespective of the above limitations, the Oregon Directory is a very useful document and consideration should be given to adapting it to the State of Idaho and, perhaps, modifying it to allow searching for federal assistance by work type rather than (or in addition to) by federal agency.

C. Federal Assistance: Specific Programs

The following section provides an overview of existing federal programs for which funding and/or technical assistance are available for landslide recovery, mitigation and investigation activities. A tabular representation of the information outlined below is provided in **Appendix F-1**.

Federal Highway Administration (FHWA)

The FHWA (of the U.S. Department of Transportation) has three transportation funding programs which, depending on the circumstances, may be available to address landslide related activities.

The **federal-aid program** is an annual distribution of funds to states to support a wide range of transportation system projects and activities. These funds are apportioned annually to states by established formulas and are managed by the states’ transportation departments as part of their annual transportation improvement programs. Typical activities for which these program funds are used include roadway construction, improvement and rehabilitation work; bicycle and pedestrian system improvements; public transit system development activities and transportation planning and research.

General limitations on the federal-aid program include:

- Non-transportation system activities are not eligible.
- Private roadways are not eligible.
- Roadways which are functionally classified as lower than major collectors are not eligible.

Idaho currently receives approximately $100M in federal-aid funds annually and typically requires a state match of 8% although this percentage will vary from 0% to 20% depending on the specific type of program funds in question.

The **Emergency Relief (ER) Program** is an established funding program available for the repair or reconstruction of highways, roads, and trails that have suffered serious damage as the result of a natural disaster over a wide area or a catastrophic failure. The general rule-of-thumb dollar figure used to define such events is that the resultant eligible damage exceeds $500 k.

The ER funds are not automatically apportioned to states but rather are available from FHWA upon request by a state in conjunction with a governor's declaration of a state of disaster or a governor's request for a major disaster declaration by the President. Concurrence by the Federal Highway Administration is needed only if the President has not issued a disaster declaration. If a President's Declaration has been issued, the Administrator only makes a finding for the eligibility of ER assistance.

The state match for the ER program is 0% during the first 180 days after the disaster for emergency repairs and approximately 8% for all permanent restoration work.

The **Emergency Relief Federally Owned (ERFO) Program** is a companion program to the ER program but for use on federally owned roadways. More specifically, the roadways covered by this program include those under the jurisdiction of the Bureau of Indian Affairs, the Bureau of Land Management, the U.S. Forest Service or the National Park Service as well as all designated Forest Highways not otherwise covered by the ER program, above.

Other differences between this program and the ER program include:

- A governor's declaration of a state of disaster is not required.
- The request for assistance is made by the affected federal agency and a determination on this request is acted upon by the Division Engineer of the corresponding FHWA Direct Federal Lands Office (Vancouver, WA for Idaho).
- There is no required match to the federal funds.

Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency has two programs which, depending on the circumstances, may be available to address landslide related activities.

The **Public Assistance Program** provides disaster recovery assistance to state agencies, local governments, any political subdivision of the state, Indian Tribes and Alaskan Native Villages. The three general types of work covered by this program are debris removal, emergency protective measures and permanent restoration. The basic eligibility criteria for the above described work types and associated costs are that they:

a. Be a result of the declared event and not a pre-disaster condition or result of some other event;

b. Be located within the area designated by FEMA as eligible for assistance;

c. Be the legal responsibility of an eligible applicant; and,

d. Not be eligible for assistance under another federal program (this applies to permanent restoration work only).

The funding under this program is available to states at the request of the governor and subject to the President's declaration of a major disaster or emergency.

The maximum state/local matching share for the funds provided under this program is 25%.

The **Hazard Mitigation Grant Program** is intended to fund projects which will result in long term impacts and produce repetitive benefits over time. The is available to state and local governments, special districts, certain private/nonprofit entities, and Indian Tribes to assist them in hazard mitigation planning and projects.

Requests for such funds should be directed through the state's Bureau of Disaster Services.

The state/local matching share for the funds provided under this program is 25%.

Economic Development Administration (EDA)

The EDA (of the U.S. Department of Commerce) is responsible for the **Flood Recovery Program** which is designed to provide economic development planning and implementation to assist in long-term economic recovery to areas impacted by disasters. Included under this program are planning and strategy grants; technical assistance grants to address specific adjustment problems and to hire disaster recovery specialists to provide operations assistance; revolving loan fund grants to provide gap financing to small businesses; and infrastructure grants for critical public facilities.

Eligible recipients for such funds include states, communities, cities, counties, and planning and development organizations.

U.S. Forest Service (USFS)

The USFS has, within its program structure, the ability to fund its own landslide recovery needs beyond those covered by the FHWA's ERFO program and including non-recovery activity such as slide mitigation work and studies. An important limitation on this funding is that it is restricted, with a few exceptions, to activities on USFS managed land.
In addition, the Forest Service has technical expertise at their Forest and Regional Offices and particularly at the Intermountain Research Station which are available to offer time, equipment and technical assistance to landslide studies and evaluations without limitation due to jurisdictional boundaries. It should be noted, however, that there exists little or no funding to support such activities and, therefore, cooperative funding arrangements would be necessary before the Forest Service could participate in such work beyond their own boundaries.

A specific landslide study program conducted by the Forest Service is the **Watershed Restoration Program**. As described, this program was established to study landslides in the federal watersheds and to identify highest priority projects through watershed analysis. While it is not know to what extent studies under this program could be initiated in Idaho, it would seem that the findings of any such previous studies would be useful to Idaho for evaluating its landslide issues.

U.S. Geological Survey (USGS)

The Geologic Division of the USGS has a **Landslide Hazard Program** designed to help states deal with emergency issues. In addition, the USGS Volcano Observatory (Vancouver, WA) has limited funding available on a cooperative basis for installation of slide warning systems through its **Volcano Hazards Program** and its **Landslide Hazard Reduction Program**.

U.S Natural Resources Conservation Service (NRCS)

The Natural Resources Conservation Service, an agency of the Department of Agriculture, is responsible for the **Emergency Watershed Program** (EWP), which is designed to provide assistance in relieving imminent hazards to life and property for floods and the products of erosion created by natural disasters that are causing a sudden impairment of a watershed. Technical and financial assistance may be made available when an emergency exists. EWP assistance can be applied to private as well as public lands. Generally, EWP assistance in not available to projects eligible for Federal Aid Highway assistance, private or public transportation, or utilities. The basic eligibility criteria are:

- Assistance provided to public or private landowners and public land managers who lack funds or resources necessary to provide relief.
- Work must be needed as a result of the declared event and not be a pre-existing condition.
- Work must reduce a threat to life or property caused by the emergency.
- Work can only restore a similar level of protection as existed prior to the event; it cannot increase the level of protection.
- Work is limited to the least costly means of removing the threat.
- Work must be economically and environmentally defensible and sound from an engineering standpoint.
- Work cannot be related to operation and maintenance.
- Work requires a legal sponsor that can obtain land rights and provide cost share.
- The maximum state/local matching share for the funds provided under this program is 25%.

The funding and technical assistance is made available by requesting assistance from the Idaho NRCS State Conservationist.

D. Federal Assistance: Gaps

While the above section identifies numerous sources of funding and assistance for landslide issues, it should be recognized that there are limitations on this assistance in terms of what circumstances are necessary before such assistance can be made available, what types of work are eligible, the jurisdictional boundaries within which the assistance can be used and the minimum state and local matching assistance required.

One specific example cited by FEMA in its discussions with the Landslide Task Force concerned the situation in which low volume, local jurisdiction roadways of relatively minor importance to the transportation system were sustaining extensive landslide damage that might warrant abandonment of the roadway when compared against the restoration cost. The frequent problem arising in this scenario is that many such roadways which previously served mainly as forest access routes also serve to accesses residences, thereby limiting the feasibility of alternatives such as roadway abandonment and/or relocation. This situation is further worsened by the fact that such local roadways are typically not eligible for FHWA funds and, unless covered by a Presidential declaration, are also not covered by any other federal funds, thus leaving the local community faced with a potentially overwhelming cost burden in order to provide service to a relatively small portion of their community.

A second funding gap, of a sort, concerns the competing interests and needs for the available funds. Specifically, with respect to the state's transportation program, it should be recognized that although the Transportation Department does have at its disposal in excess of $200M in state and federal funds each year which can be used for a variety of transportation related activities including landslide mitigation work and studies, the state's transportation program is, according to its 1995 Idaho Highway Needs Assessment Study Update, projected to have a backlog of unmet needs in excess of $5.9 B by 2000 based on currently projected funding forecasts. As a result, many identified landslide needs, while eligible for such funds, will still go unfunded unless it can be demonstrated that such work is sufficiently important to the state to warrant its prioritization ahead of other competing needs.

IV. FEDERAL ASSISTANCE: STRATEGIES

In considering the state's significant landslide mitigation and recovery needs, it is obvious that there are not sufficient resources to address all that might be done. Recognizing this, the state must focus its efforts on taking the best advantage of all resources available to it. Some general strategies to consider in this regard include:

A. Recovery Work

To expedite the funding processes, the state should be prepared to identify and report all eligible damage as soon as possible following its occurrence.

To maximize the use of the funding assistance programs, the state should be familiar with all available federal assistance programs, including the eligibility criteria and limitations under which such assistance is available, the match ratio requirements, the procedures to follow for requesting such assistance and the contacts for guidance and/or processing of requests for assistance.

B. Mitigation Work

To improve the chances of securing ITD's transportation program funding for landslide mitigation work, the state should identify its landslide mitigation needs, develop project concepts to address these needs and prioritize the projects in terms of their benefit/cost ratio.

To improve the chances of securing FEMA's Hazard Mitigation Grant Program funding for landslide mitigation work, the state should consider developing hazard mitigation plans outlining proposed projects and other mitigation actions.

C. Studies

To make the greatest use of available technical and funding assistance, the state should coordinate with the appropriate federal and state resource agencies as well as the University of Idaho to seek their involvement and cooperative assistance in any proposed landslide studies.

V. RECOMMENDATIONS

1. The state should identify and thoroughly review all available federal assistance programs and develop strategies to take best advantage of these resources.

2. The state should pursue the development and utilization of a landslide management system as a decision making tool for prioritizing midterm and long-term landslide needs. Such a system would assist the state in making decisions concerning the extent to which existing state and federal funds should be diverted from other program activities to slide mitigation efforts.

3. The state should identify potential funding gaps in landslide recovery and mitigation activities and consider what actions can and should be taken to address them.

TASK FORCE PARTICIPANTS

TASK FORCE WORKING MEMBERS	
Name	**Agency Represented**
Barta, Alan	US Forest Service-Intermountain Research Station
Bennet, Doug	US Bureau of Reclamation
Carter, Brent	US Bureau of Reclamation
Carter, Deb	National Marine Fisheries Service
Clayton, Jim Crowther, Derrick	US Forest Service-Intermountain Research Station Kleinfelder Inc.
Curtis, Jim	US Forest Service-Boise National Forest
Donato, Mary	US Geological Survey
Frey, Scott	Federal Highway Administration
Gillerman, Virginia	Idaho Geological Survey
Guerra, Ernie	Senator Dirk Kempthorne's Office
Heberger, Roy	US Fish and Wildlife Service
Heimer, John	Idaho Department of Fish and Game
Hornbaker, Sonny	Idaho Department of Water Resources
Jannuzzi, John	National Weather Service
Kendrick, Cordell	US Department of Agriculture-Farm Service Agency
Link, Dick	US Bureau of Reclamation
Lockhart, Allen C.	US Bureau of Reclamation
McKellar, Bruce	Morrison Knudson
Nottingham, Keith	Idaho Transportation Department
Patton, Wayne	US Forest Service-Boise National Forest
Sharma, Sunil	University of Idaho
Stevenson, Terril	Natural Resources Conservation Service
Weinbrecht, Carl	National Weather Service
Weiser, Stephen	Idaho Bureau of Disaster Services

ATTENDEES AT MEETINGS

Name	Agency Represented
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Arnold, John	Arnold Associates
Bosold, Michael	Document Consultant
Braasch, Sara	Senator Larry Craig’s Office
Carpenter, Phil	Federal Emergency Management Agency
Choate, Phil	Ida-Ore Planning and Development
Cline, John	Idaho Bureau of Disaster Services
Darakjy, Damon R	Governor Phil Batt’s Office
Dixon, Michael	US Forest Service-Payette National Forest
Freitag, Bob	Federal Emergency Management Agency
Frischmuth, Patrick	Idaho Bureau of Disaster Services
Goodwin, Peter	University of Idaho
Langhelm, Ron	Federal Emergency Management Agency
Massey, Patrick	Federal Emergency Management Agency
May, Fred	Utah Comprehensive Emergency Management
McGourty, Pat	Federal Emergency Management Agency
McKnight, Jim	Idaho Bureau of Disaster Services
Meador, Wendy	Federal Emergency Management Agency
Meek, Clark D.	Idaho Bureau of Disaster Services
O’Brien, Jim	FLO Engineering
Schweitzer, Rick	Idaho Power Company
Seronko, Paul	US Bureau of Land Management
Wayleth, Merrie	Federal Emergency Management Agency
Wasniewski, Louis	USDA Payette
Zinke, Dave	Morrison Knudsen

GLOSSARY

Alluvial fan: A cone-shaped, gently sloping mass of alluvium typically deposited where a stream exits a canyon onto a valley floor.

Alluvium: Sediment deposited by running water.

Batholith: A large body of plutonic rock.

Cohesion: The capacity of a soil to stick or adhere together

Colluvium: Sediment moved downslope by gravity and not by running water.

Debris cone: A steep cone shaped mass of colluvium typically located where steep channels meet the valley floor. Debris fans can be differentiated from alluvial fans by their gradient (steeper), sediment size (coarser), their stratigraphy (often matrix supported and poorly sorted), and the processes of formation (colluvial rather than alluvial).

Debris flow: A moving mixture of boulders and mud that is usually the result of the rapid accumulation of surface water. Debris flows travel rapidly and a considerable distance.

Fluvial reworking: The reworking of colluvium by running water after a debris flow or other mass movement. Many colluvial deposits have a surface veneer of alluvium.

Hazard: A source of danger to communities, structures, and resources.

Hydraulic conductivity: A measure of how quickly water travels through rock or soil.

Hyperconcentrated flow: A flowing mixture of sediment and water, usually between 40% and 80% sediment by weight, that has a measurable strength but still appears to flow like a liquid. a flowing mixture of sediment and water, usually between 40% and 80% sediment by weight, that has a measurable strength but still appears to flow like a liquid.

Igneous: A type of rock formed by solidification from the molten state. Basalt and granite are examples of igneous rocks.

Infiltration capacity: The ability of soil to take in water by seepage.

Landslide: In the strict sense, the downslope movement of a volume of rock or earth *as a unit* due to a failure of the material. For convenience and stylistic brevity, the term landslide is often used in this report to describe any downslope movement of a surface materials (i.e. debris flow, rotational failure, etc.).

Landslide mitigation: Actions taken to lessen the loss or damage (to life, property, ecosystems) as a result of landslides that may occur in the future. Examples of possible mitigation measures include: mapping of landslide hazard areas, slope terracing, road relocation, ordinances limiting development in hazardous areas.

Metamorphic: A type of rock formed by recrystallization under high temperatures and pressures deep in the earth, but not melted, as an igneous rock.

Mica: A family of minerals, including biotite, muscovite, and chlorite, whose layered sheet-like crystal structure makes them flat and platy. This causes micas to break easily along the planar direction.

Mitigate: To cause to become less severe; specifically, to reduce future losses to life, property, and revenue and to prevent the disruption of critical services and the economy.

Overland flow: Water which drains across the land to a stream channel; also called surface flow.

Permeability: The capacity of soil or rock for transmitting a fluid.

Plutonic: A type of igneous rock that formed beneath the surface of the earth by consolidation from the molten state. A synonym is *intrusive*. Granite is one type of plutonic rock.

Pore-water pressure: The pressure exerted by water contained in the voids in soil and rock. The more saturated the material is, the higher the pore-water pressure is. This pressure can force particles apart, thus lowering the material strength, which can lead to failure.

Return period (or recurrence interval): The *average* length of time separating events of a similar magnitude. For example, if a flood of a given magnitude has a 50-year return period, then in any given year there is a 1-in-50 chance of a similar or larger flood occurring.

Risk: The economic consequences of a hazard.

Shear strength: The maximum resistance of a material to applied stress. When the shearing stress exceeds the shear strength of the material, it will fail.

Soil: Soil scientists and engineering geologists define soil differently. For the soil scientist, soil is the thin layer of unconsolidated material that covers much of the earth's crust, has developed a characteristic structure *in situ*, and is suitable for plant growth. To the engineering geologist, soil is all unconsolidated material above bedrock.